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THE OCCURRENCE OF A COTTON BOLL WEEVIL IN ARIZONA

By W. DWIGHT PIERCE,
Agent and Expert, Investigations of Insects Affecting Southern Field Crops, Bureau of Entomology

The preliminary announcement by Mr. O. F. Cook, of the Bureau of Plant Industry, in February, 1913, of the occurrence in Arizona of a weevil resembling the Mexican cotton boll weevil, appears at this time to have been an announcement of considerable importance. In company with Mr. Harold Bell Wright, Mr. Cook found this weevil breeding in the bolls of a wild shrub known as *Thurberia thespesioides* in Ventana Canyon, Santa Catalina Mountains, Arizona.

In May the writer obtained a large quantity of bolls of Thurberia from Mr. W. B. McCleary, of the Bureau of Plant Industry, who collected them in the lower part of Stone Cabin Canyon, Santa Rita Mountains, Arizona. This material was very heavily infested by the weevil.

During August Dr. A. W. Morrill, State Entomologist of Arizona, together with the writer, located this weevil in Ventana Canyon, Santa Catalina Mountains, and in Sawmill Canyon, Santa Rita Mountains, breeding commonly upon the same plant.

A close examination of the material received early in the year disclosed many minor points of difference from the usual form of the cotton boll weevil, *Anthonomus grandis* Boheman. The Arizona form averages slightly larger and is a little more robust. The punctation of the male beak is a little more pronounced, and the sculpturing throughout is slightly stronger than in the Texas form. The scaly vestiture approaches a golden color, while in the Texas form it is usually grayish. The sides of the prothorax in front are rarely emarginate, while the emargination is usually very noticeable in the Texas form. Minor differences also appear in the shape of the teeth on the legs. All in all, the adults of the Arizona weevil present an assemblage of characters differing from the eastern form sufficient to suggest a new species.

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In addition to these differences in characters, specimens of the Arizona form were found in hibernation in their cells until September 1, while the eastern form is never found in its cells in cotton bolls after March 15. The Arizona insect seems to be confined to one, or not more than two, annual generations, while the cotton boll weevil has many generations. The former lives on Thurberia, the latter on Gossypium. The Arizona weevil was found at 4,000 feet altitude, while the Texas weevil has never been found above 2,000 feet altitude. The two forms are geographically isolated by mountain divides. When the Arizona weevil was seen in the field, it displayed a tendency to oviposit at a different place and to seal its egg puncture differently; the egg itself was of a slightly different shape.

The Mexican cotton boll weevil has never been known before this year to feed readily or breed in any other plant, although suspected of being capable of adapting itself to other foods if forced to it. When opportunity was given the Texas boll weevil to attack Thurberia squares and bolls, it fed readily and eagerly, sometimes displaying a preference for Thurberia over cotton when both were available. The Thurberia-feeding weevil, on the other hand, was able to feed upon and breed in cotton squares.

Mr. B. R. Coad, of the Bureau of Entomology, has succeeded in rearing undoubted crosses between the two varieties from females of each form, although these hybrid offspring were somewhat undersized.

It will be seen from further evidence in this paper that the two forms must represent merely two subspecies, or varieties, or geographic races of a single species. The Arizona form is therefore to be known as *Anthonomus grandis thurberiae*, new variety. Its technical description is as follows:

Anthonomus grandis thurberiae, n. var.—Stout, subovate, rufo-piceous, and clothed with coarse, pale-yellowish pubescence. Beak long, slender, shining, and sparsely pubescent at the base; striate from base to the middle, striæ rather coarsely punctured; apical half finely and remotely punctured. Antennæ slender, second joint of funicle longer than the third; joints 3 to 7 equal in length but becoming gradually wider. Head conical, pubescent, coarsely but remotely punctured, front foveate. Eyes moderately convex, posterior margin not free. Prothorax one-half wider than long; base feebly bisinuate, posterior angles rectangular; sides almost straight from base to middle, strongly rounded in front; apex slightly constricted and transversely impressed behind the anterior margin; surface moderately convex, densely and subconfluently punctured; punctures irregular in size, coarser about the sides; pubescence more dense along the median line and on the sides. Elytra oblong, scarcely wider at the base than the prothorax; sides robust to subparallel for two-thirds of their length, thence gradually narrowed to, and separately rounded at the apex, leaving the pygidium moderately exposed; striæ deep, punctures large and approximate; interstices convex, rugulose, pubescence somewhat condensed in spots. Legs rather stout, femora clavate, anterior strongly bidentate, inner tooth long and strong, outer one acutely triangular and connected with the former at the base; middle femora with small second tooth and posterior femora unidentate. Tibiæ moderately stout, anterior bisinuate internally, posterior straight; tarsi moderate, claws broad, blackish, and

rather widely separate; tooth almost as long as claw. Length, 5 to 5.5 mm. (0.20 to 0.22 inch).

This variety differs from *Anthonomus grandis* on cotton by its greater robustness (Pl. VI); the more golden appearance of the scales; the slighter constriction of the prothorax (figs. 1 and 2); its stouter and more coarsely sculptured beak (figs. 3 and 4); its slightly more compact antennæ (figs. 5 and 6), with funicle of a lighter color than the club; its stouter legs, with a distinct second tooth on the middle femora (figs. 7 and 8); the wing (fig. 9), which shows a slightly more distinct spot. It also differs in its food plant (*Thurberia thespesioides*), its altitude (4,000 feet upward), its breeding season (August 15 to November), and in certain physiological and biological characters. The most obvious diagnostic characters are as follows:

Anthonomus grandis thurberiae	Anthonomus grandis
Antennal funicle of a distinctly lighter color than the club; punctation of elytral striæ strongly and clearly defined; prothorax usually very feebly constricted and not emarginate or but very slightly so; elytra often robust; vestiture of ochreous scales intermixed with black hairs; breeds in *Thurberia thespesioides*; range, above altitude of 4,000 feet.	Antennal funicle and club concolorous; punctation of elytral striæ not clearly defined from the striæ; prothorax strongly constricted at apex and usually emarginate in front; sides of elytra usually parallel; vestiture of grayish to ochreous scales intermixed with very inconspicuous grayish to very dark-brown hairs; breeds in *Gossypium* spp.; range, below altitude of 2,000 feet.

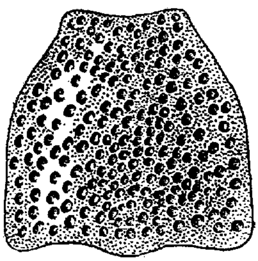


FIG. 1.—*Anthonomus grandis*, var. *thurberiae*: Prothorax. Much enlarged. (Original.)

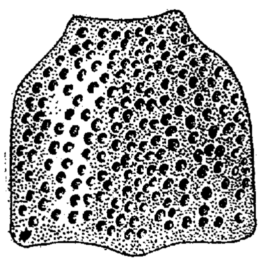


FIG. 2.—*Anthonomus grandis* Boh.: Prothorax. Much enlarged. (Original.)

HIBERNATION.—It is not known whether *Anthonomus grandis thurberiae* hibernates as an adult outside of its cell, but it is known positively that many individuals pass the winter and even the summer in the cells formed during the preceding fall. In May, 1913, from the material sent by Mr. McCleary, the writer found 18 live adults in their cells in an examination of 743 bolls, 220 of which were infested. On August 27 Dr. Morrill found six live boll weevils still in their last year's cells at about 4,500 feet altitude in Sawmill Canyon, Santa Rita Mountains, and on August 30 the writer found another live weevil in its cell in Ventana Canyon, Santa Catalina Mountains.

As further evidence of the prolonged rest of this variety, no immature stages were found, beyond a one-fifth grown larva in squares. The extreme lateness of the plants in the canyons where the boll weevil was found indicated that the weevils could not have had buds on which to feed for much more than two weeks in August. Plants grown from seed at Victoria, Tex., and Tallulah, La., did not begin to produce buds until well along in August. The natural dormant period of the Arizona boll weevil therefore lasts about nine months.

It is interesting to note that the Thurberia weevils extracted from their cells in May and sent to Victoria, Tex., immediately began to feed and breed upon cotton and produced several generations.

The Arizona form has either acquired by long years of adversity an ability to survive for a longer period without food, assuming *Anthonomus grandis* Boh. to be the original species; or if the Thurberia weevil is the true original form, then the ability to obtain a plentiful supply of early food has caused the species to lose some of its resistance to adversity.

FEEDING.—The adults feed upon the squares and bolls in much the same manner as the typical *Anthonomus grandis*.

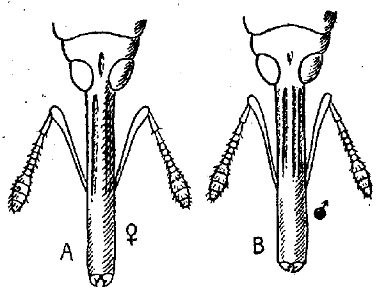


FIG. 3.—*Anthonomus grandis*, var. *thurberiae*: Head and beak: *A*, Female; *B*, male. Much enlarged. (Original.)

FEIGNING DEATH.—The adults are not quite so easily disturbed as those of the cotton-feeding form, but when disturbed they feign death and drop to the ground or fly away.

OVIPOSITION.—On the first day that any adults were seen, August 25, in the Santa Rita Mountains, the males were the most abundant and usually were not feeding, but were perched on the tips of squares or on the foliage in an attentive attitude, evidently waiting for females.

The egg puncture is almost always made at the base of the square, and the hole is sealed by a gelatinous scale exuded by the plant, over which there is often a small mass of excrement. On removal of this scale the egg can often be seen. A majority of the eggs seen were twice as long as broad, and only one was of the same proportions as usually found in *Anthonomus grandis*. In the bolls the position of the egg puncture is more general.

DEVELOPMENT.—The developmental period of the Arizona weevil on its native host has not been studied, but it has been watched by Mr. Coad at Victoria, Tex., on cotton. The period is practically the same as for Texas weevils, beginning on the same day: In June, 16 days; in July, 12.5 days; in September, 17.2 days. The period in bolls in September is naturally longer, and no specimens had been carried completely through at the time of writing this article.

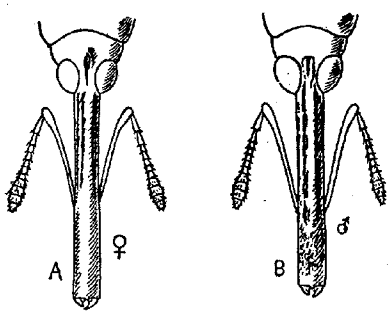


FIG. 4.—*Anthonomus grandis* Boh.: Head and beak: *A*, Female; *B*, male. Much enlarged. (Original.)

The most interesting point in the Victoria work lies in the fact that in June, when this boll weevil was removed from hibernation and transplanted on cotton, it was able to begin its generations immediately and to continue reproduction throughout the season.

The food plant of this new variety is known botanically as *Thurberia thespesioides*, although it has also been called *Gossypium thurberi* and *Ingenhouzia triloba*. It occurs in southwestern Chihuahua and Guadalajara, Mexico; in the Santa Catalina, Santa Rita, Tanque Verde, Rincon,

Mule Pass, Huachuca, and Chiricahua Mountains, and also in Fish Creek Canyon of the upper Salt River valley, and at Dragoon, Fort Bowie, and Davidson Springs, all in Arizona.

Thurberia grows at altitudes from 2,250 feet to 7,000 feet, and is found in the bottom of the canyons, on the canyon walls, and on top of the ridges, growing usually where protected more or less from the greatest heat of the sun.

The plant begins flowering in some localities in July, but in others it is just beginning to bud in the latter part of August. Flowering continues into October.

In appearance Thurberia is so nearly like cotton that the Mexicans and natives call it "wild cotton." The leaves are simple, or 3 or 5 lobed, and in the two latter forms resemble the okra-like form of Upland cotton (*Gossypium hirsutum*) or the normal leaves of the Mexican species *Gossypium palmeri* Watt. and *G. schottii* Watt. The leaf has a nectary on the

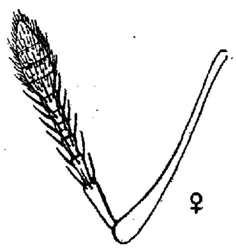


FIG. 5.—*Anthonomus grandis*, var. *thurberiae*: Antenna of female. Much enlarged. (Original.)

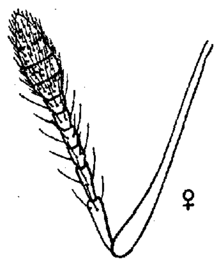


FIG. 6.—*Anthonomus grandis* Boh.; Antenna of female. Much enlarged. (Original.)

midrib, like cotton, and this nectary is as attractive to insect life as the leaf nectaries of Egyptian or Upland cotton. The buds differ from cotton buds by the truncate calyx cup and the linear involucral bracts, but the three nectaries, which also prove a great attraction to insects, are present as on cotton squares. The flowers resemble cotton flowers very closely. The bolls are small, not over three-fourths of an inch in length, and are 3 to 5 celled, with two rows of seed in each. There is a very tiny fiber on the cell walls.

The plants are perennial, growing to be over 10 feet high, with a spread of about 10 feet, and having a large, strong, woody trunk. They are very prolific fruiters. The species is often killed back by frosts, as is evidenced by the dead terminals with the old bolls of previous seasons. The heavy wash in the mountain canyons is one of the principal means of dispersion of the plant.

Thurberia is exceedingly like cotton in most essentials, the relationship being most clearly demonstrated by the many insects which attack both.

At least two species of parasites attack the Arizona "wild-cotton" boll weevil in the Santa Rita Mountains. One of these is a species of Cerambycobius and the other is a braconid. There are also some predators which attack it.

Without further information it is idle to speculate as to the direction of the adaptation which has evidently taken place in *Anthonomus grandis*. If further research should locate this boll weevil breeding upon another genus of plants closely related to cotton, such as Eremoxylum, a genus of western Mexico, or upon one of the small wild species of Gossypium in Mexico, the direction of adaptation might be traced. Some of the

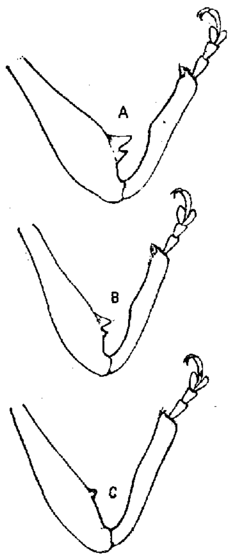


FIG. 7.—*Anthonomus grandis*, var. *thurberiae*: *A*, Front leg; *B*, middle leg; *C*, hind leg. Much enlarged. (Original.)

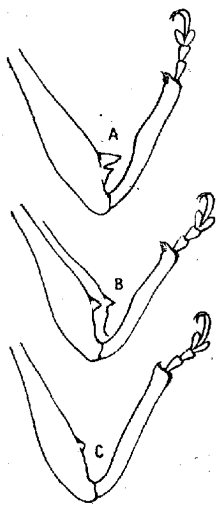


FIG. 8.—*Anthonomus grandis* Boh.: *A*, Front leg; *B*, middle leg; *C*, hind leg. Much enlarged. (Original.)

differences in the condition of the two varieties which show the range of adaptivity of the insect are as follows:

The rainfall in the vicinity of Tucson, Ariz., for 40 years has averaged only 11.66 inches per annum, not reaching 3 inches in any month. July and August are the months of greatest precipitation.

The rainfall at Victoria, Tex., for 20 years has averaged 36.63 inches per annum, with over 3 inches in seven months of the year. May is the month of greatest precipitation.

The rainfall at Opelousas, La., for 17 years has averaged 57.12 inches per annum, with over 5 inches in six months of the year. July is the month of greatest precipitation.

The altitude of Opelousas is 83 feet, of Victoria 145 feet, and of Tucson 2,390 feet. The Arizona boll weevil is found at 4,000 feet altitude and higher. The highest altitude at which the Texas form has been found on cotton is under 2,000 feet.

The maximum temperature at Opelousas and Victoria is 104° F., and at Tucson 112°. The minimum temperature at Opelousas is 2°, at Victoria 6°, at Tucson 10°. The mean temperature at Opelousas is 67.3°, at Victoria 70°, at Tucson 68°. The average date of first killing frost in the fall for Opelousas is November 17; Victoria, December 10; and for Tucson, November 22. The average date of last killing frost in spring for Opelousas is March 5; for Victoria, February 20; and for Tucson, March 26. At Tucson, August is the only month in which the minimum temperature does not run below 56° F., which is the zero of effective temperature for *Anthonomus grandis* in Texas. At Victoria and Opelousas the minimum never goes below 56° in July or August.

Of course, in the mountains where *Anthonomus grandis thurberiae* occurs the temperature does not reach quite as high a point as at Tucson, and the minimum temperature is lower. The chilly nights and warm days probably would retard the development and hibernation of the cotton boll weevil in the same manner if transplanted to Arizona mountain conditions.

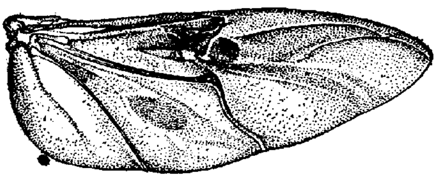


FIG. 9.—*Anthonomus grandis*, var. *thurberiae:* Wing.

The points of greatest adaptation are evidently atmospheric pressure and humidity, and possibly high temperature, although typical individuals of *Anthonomus grandis* have been known to survive 114° F. at Dallas, Tex., while the excessive drought experienced for several years in northern Texas practically exterminated the species.

Cotton is cultivated in the Imperial Valley and the Colorado River valley in California, in the Salt River valley, the Gila River valley in eastern and central Arizona, and also in the Santa Cruz River valley of Arizona.

The varieties grown are mainly long staple—Egyptian and Durango, with some Triumph. The crops, which are irrigated, are very promising and can be made with very little water if it is properly applied.

The Arizona "wild cotton," Thurberia, occurs in nearly every mountain range in southwestern Arizona where there is any moisture. In the vicinity of the Santa Cruz Valley cotton is grown within 5 miles of Thurberia plants growing in the mountains. The boll weevil was not found on the nearest Thurberia plants, nor were many of the nearest canyons investigated, but it was found to be abundant not more than 10 miles distant. This is the first year of cotton in the Santa Cruz Valley, and it is expected that a large acreage will be planted in 1914.

Thurberia is known to occur in Fish Creek Canyon, one of the sources of the Salt River. This valley has the most extensive cotton plantings in Arizona. However, the boll weevil has not been observed there.

No observations have been made in the vicinity of the Gila River valley, but as Thurberia occurs in the mountains both north and south of this valley, it undoubtedly also occurs in some of the ranges bordering the valley.

The Arizona weevil may be able to cover considerable distances by flight, especially if compelled to seek sustenance elsewhere. However, it will probably cleave to its native food plant as long as this gives sufficiently abundant food, though a great increase of weevils or a decrease of food might drive them to seek other food. They would take more readily to cotton than anything else, and once they find the rich, succulent cotton, with its plentiful food and moistened soil, they will probably do serious damage. It is to be feared that a wholesale destruction of the native food plant might invite a quicker than natural adaptation to cotton on the part of this western weevil. This matter is now under investigation, but at the present time it is the writer's personal opinion that the safest plan is to preserve the status quo of the weevil in the mountains. An introduction of parasites from the cotton boll weevil would be of considerable assistance in reducing the Arizona weevil and would not cause its dispersal.

There is danger of a distribution of weevil-infested buds through the drainage system by summer freshets. After such occurrences the cotton should be watched very closely for several weeks for the appearance of weevils.

The cotton boll weevil has never been able to successfully invade the drier cotton sections of western and northwestern Texas, although it has been expected that it will gradually adapt itself to the more rigid conditions of these sections. It is of extreme importance that the Arizona weevil be kept out of western Texas and any part of the southeast, except when under very careful isolated observation of specialists. If accidentally introduced into other sections, the Thurberia weevil might be able to stand much greater variations of climate than *Anthonomus grandis* Boh. and become a much more powerful pest. Furthermore, there is every reason to believe that *Anthonomus grandis thurberiae* could withstand the rigors of the climate of western Texas.

It is therefore important that restriction by quarantine be considered, and this matter will be taken up at an early date by the Federal Horticultural Board.

DESCRIPTION OF PLATE

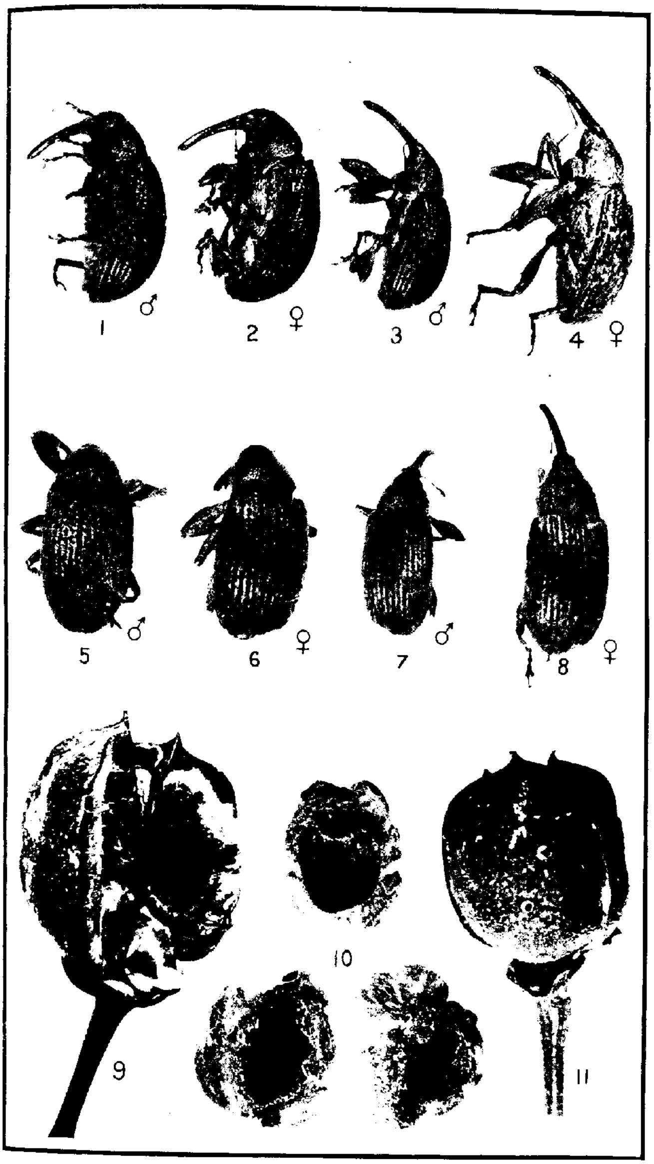
PLATE VI. Figs. 1, 2, 5, and 6.—*Anthonomus grandis thurberiae*: Type specimens; actual length, 5.5 to 6 mm. Figs. 1 and 5.—Side and dorsal views of male. Figs. 2 and 6.—Side and dorsal views of female. Enlarged. (Original.)

Figs. 3, 4, 7, and 8.—*Anthonomus grandis*: Typical specimens; actual length, 5.5 to 6 mm. Figs. 3 and 7.—Side and dorsal views of female. Enlarged. (Original.)

Fig. 9.—*Thurberia thespesioides:* Section of boll, showing cell of *Anthonomus grandis thurberiae*. Enlarged. (Original.)

Fig. 10.—*Thurberia thespesioides:* Seed, showing cell of *Anthonomus grandis thurberiae*. Enlarged. (Original.)

Fig. 11.—*Thurberia thespesioides:* Boll, showing egg puncture of *Anthonomus grandis thurberiae*. Enlarged. (Original.)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THE DIAGNOSIS OF DOURINE BY COMPLEMENT FIXATION

By John R. Mohler, Adolph Eichhorn, and John M. Buck,
Pathological Division, Bureau of Animal Industry

INTRODUCTION

Dourine is a specific infectious disease affecting under natural conditions only the horse and the ass, transmitted from animal to animal by the act of copulation, and due to a single-celled animal parasite or protozoan, the *Trypanosoma equiperdum*. It is characterized by an irregular incubation period, the confinement of the first symptoms to the genital tract, the chronic course which it runs, and by finally producing complete paralysis of the posterior extremities, with a fatal termination, as a rule, in from six months to two years.

HISTORY OF DOURINE IN THE UNITED STATES

In the United States the disease was first suspected in 1885 and recognized in 1886 by Dr. W. L. Williams, who was then a veterinary practitioner at Bloomington, Ill. Officials of the State of Illinois took hold of the outbreak, and as a result of rigid prophylactic measures the disease was eradicated from the State in 1888, but not before an affected stallion had been shipped to Gordon, Nebr., thereby starting up a new center of infection in that locality.

In 1892 dourine was again brought into public notice by an outbreak among the breeding horses of northwestern Nebraska, the history of which suggested that it originated with this Gordon stallion. After an expenditure of about $5,500 by the Bureau of Animal Industry the disease was considered to have been eradicated from that section of the country. Five years later the infection again made its appearance in the same part of Nebraska, and early in 1899 the Bureau again began the work of eradication. Many inspections were made, and those animals which were found diseased were purchased and killed. Many obstacles were encountered, and the disease evidently kept smoldering during 1900.

In 1901 the infection reappeared with increased vigor, this time in the Pine Ridge and Rosebud Indian Reservations in South Dakota, in addition to northern Nebraska, and more stringent measures were immediately inaugurated to control the spread of the disease. However, eradication in this region was extremely difficult, owing to the wildness

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of the country as well as of the horses and the fact that many horse owners would try to conceal from the inspectors animals which they knew to be affected with the disease. In 1906 the last suspicious cases of dourine were destroyed in South Dakota.

In the meantime, during the year 1903, dourine was reported in Van Buren County, Iowa, and successful steps were immediately taken to stamp it out. No connection could be established between this outbreak and that in Nebraska, but it was quite definitely determined that an imported Percheron stallion purchased by a company of farmers was responsible for its appearance.

Another outbreak of dourine was discovered in Taylor County, Iowa, in 1911. The diseased animals, together with all exposed stallions and mares, were immediately quarantined by the State. Those showing lesions of the disease and those exposed horses that reacted to the complement-fixation test were purchased by the Government and destroyed. It is now believed that the infection is entirely eradicated from Iowa. The source from which this center of infection was derived is only a matter of conjecture, but there is apparently no connection between this and any of the previous outbreaks. No authentic information as to the origin of the outbreak was discovered, but all cases lead back to a Percheron stallion which was imported in 1909 and brought direct to Lenox, Iowa.

Early in July, 1912, the State Veterinarian of Montana reported several suspicious cases of dourine in eastern Montana and forwarded blood sera from the suspected animals for the complement-fixation test. All but one sample gave positive results, thus establishing a new center of infection of dourine. From present indications this outbreak appears to be more extensive than any of the previous outbreaks, involving also two Indian reservations in North Dakota and South Dakota; but a force of 12 Federal veterinarians assisted by State representatives is at work on the disease, and the infection is well under control.

SEARCH FOR A METHOD OF DIAGNOSIS

The difficulty of diagnosing chronic and latent forms of dourine is generally recognized, and owing to this fact the control and eradication of this disease in horses has been of slow progress and sometimes ineffective. In such outbreaks it has been the custom to trace the disease as far as possible to its origin and then to keep under observation all mares and stallions which directly or indirectly have been exposed to the disease. At the same time animals which show clinical evidences of the affection are destroyed without delay. By this means several of the outbreaks which have occurred in the United States have been checked and eradicated.

The attempt to make a microscopical demonstration of the *Trypanosoma equiperdum* in affected horses is very frequently unsuccessful,

although our more recent experience proves that the organism may occasionally be found in the serous exudate of the plaques and also in the fluid of the edematous swellings of the genital organs in the stallions as well as in the mares.

Of course, this procedure of diagnosis can be attempted only when the disease occurs in farming localities where the animals can be readily observed and examined as desired. On the other hand, in the present outbreak in Montana and adjoining States the conditions make the diagnosis by the demonstration of trypanosomes impossible, and, likewise, animal inoculations can not be satisfactorily utilized for this purpose. Horses in that locality are bred under range conditions; they run wild and a round-up takes place only once a year. The difficulty of an examination, even clinically, of such animals is obvious, since they have not been broken to the halter and are troublesome to handle.

Our experience with the disease in Montana showed that only a limited number of animals were clinically affected. Nevertheless, the association of all the animals without any restriction in the breeding periods indicated that a larger number of animals would be found infected, which, as a matter of fact, has been proved by subsequent tests, as hereinafter shown.

Owing to the fact that until the last few years the eradication of dourine in this country was supposed to have been complete, the disease has received only slight attention as compared with other menacing diseases of our domesticated animals. It was not until the outbreak in the State of Iowa in 1911 that the necessity for devising a method of diagnosing this infection began to be fully realized. The value of being able to detect the latent and to verify the clinical cases became apparent. Otherwise, the necessity existed of maintaining a long-continued quarantine in those sections of the country where cases have been discovered. While little difficulty has been experienced in recognizing the advanced cases, a clinical examination alone naturally permitted many infected animals to escape detection, only to facilitate the further spread of the disease until the appearance of symptoms made the diagnosis unquestionable.

Inasmuch as the complement-fixation method of diagnosis has been employed with gratifying results in connection with numerous other diseases, the possibility of applying this method to dourine naturally suggested itself, and steps were therefore taken to determine the feasibility of its application to this disease.

It was very early discovered that the problem of preparing a satisfactory antigen would offer considerable difficulty. Efforts were primarily directed toward utilizing for this purpose the different organs of those horses that had succumbed to the disease. Several of the clinical cases were shipped from Iowa to the Bethesda Experiment Station during the outbreak referred to, in order that a more complete observa-

tion might be made of the development of the disease and that material might at the same time be available for the preparation of an antigen. From time to time, as these animals died, certain tissues were obtained which it was suspected might furnish the desired results, but although shake extracts of the spleens, livers, kidneys, and bone marrow, as well as alcoholic and acetone preparations, were employed under various conditions, the results were rather discouraging.

Subsequent to this time there came under our observation publications by numerous investigators who had given this subject consideration. It will suffice to mention the publications of Landsteiner, Müller and Pötzl, Levaditi and Yamanouchi, Hartoch and Yakimoff, Citron, Weber, Manteufel, Manteufel and Woithe, Zwick and Fischer, and Schilling, Claus, and Hösslin. The results in these instances appeared to have been unsatisfactory, which was also the case in the extensive work on the diagnosis of dourine by the Wassermann method by Trajan Pavlosévici, as he concluded that while antibodies can be demonstrated by this method in laboratory animals infected with trypanosomes, the method can not be utilized in stallions affected with dourine.

Later, Winkler and Wyschelessky, Mohler, and also Watson in their work on complement fixation as an aid in the recognition of trypanosomiasis indicated the good results obtained in the diagnosis of dourine. Likewise, Mattes in his work on the agglutination of trypanosomes obtained gratifying results, while Braun also concludes that complement fixation can be utilized for the diagnosis of trypanosome affections.

In the recorded publications it was observed that the more promising results were obtained by those who employed suspensions of pure trypanosomes. The organ extracts and other preparations of antigens generally used for this purpose proved unreliable. The procedure as recommended by various workers in obtaining an antigen from pure trypanosomes and using such a suspension as the antigen has also been tried by the writers with uniformly good results. The practical application of this procedure, however, would be very laborious and require a great deal of time, especially in cases where a large number of horses have to be tested by this method. Accordingly it was deemed advisable to devise a means by which an antigen could be prepared which would give similarly good results but would not require such delicate and laborious technique. In place of the specific trypanosome of dourine being utilized, the writers selected the surra organism, as it had been previously ascertained by several investigators that the reaction obtained was not absolutely specific for any one trpyanosome infection but was rather of a group nature. As dourine is the only known trypanosome affection of horses existing in this country, the value of even a group reaction was immediately appreciated, and attention was directed to the carrying out of this idea in our diagnostic work.

In place of preparing suspensions of the trypanosomes, however, an antigen was made of the blood and macerated spleens of rats killed at the height of surra infection. This material was placed in a bottle containing glass beads and shaken for six hours, filtered through gauze, and carbolized. The results from this antigen proved satisfactory, and it was used repeatedly on the blood of the horses affected with dourine that were left of the Iowa shipment.

The smallest quantity of the serum which gave a positive reaction with the antigen was 0.05 c. c.; however, the various comparative tests indicated that fixation in tubes containing 0.2 c. c. of serum is sufficient for diagnostic purposes. Sera from normal animals, also those affected with various other diseases, failed to give a reaction. This antigen proved active on 10 consecutive days, but failed to produce fixation of complement on subsequent tests. Later attempts by the same procedure also resulted less satisfactorily, and it was therefore deemed advisable to try other methods in order to procure an antigen of more uniform action.

The following procedure was next employed:

After successive examinations of the blood of a dog infected with surra, about 200 c. c. of blood were drawn from the jugular vein when the microscopic examination revealed an extreme infestation with the parasite. The blood was drawn into a 1 per cent potassium-citrate solution in large centrifuge tubes of 100 c. c. capacity. A quantity of potassium-citrate solution was used equal to the amount of blood drawn into each tube, and 0.5 gram of saponin was added to each tube in order to dissolve the red blood corpuscles. After a thorough shaking and after complete hemolysis had taken place, the tube was centrifuged for 30 minutes at 2,500 revolutions, and the supernatant fluid was siphoned off. The residue, which was of an opaque color and consisted principally of trypanosomes, was then thoroughly mixed and shaken up with salt solution, when it was again placed in the centrifuge; this washing was repeated three times. After the last washing the thrown-down opaque mass was emulsified with 50 c. c. of salt solution and titered as to its merits as an antigen for dourine tests. The results were highly satisfactory, and the titer was established at 0.5 c. c. of this emulsion per tube. However, the disadvantages of this method—namely, the difficulty in the preparation of this antigen and also the small quantity which was obtainable from a single bleeding of a dog—were soon apparent.

In July, 1912, the outbreak of dourine in Montana was discovered, as already mentioned. Several samples of blood sera from clinical cases were forwarded by the State authorities to the Bureau of Animal Industry for verification. Positive reactions were obtained in numerous instances with antigens thus prepared, establishing conclusively the presence of the disease in that State, as well as suggesting the possibilities of the test as a means of its eradication. It was not long before dis-

covery was made that the disease was quite widely spread in Montana owing to the previous failure to recognize it. In an endeavor to comply with the request of the State authorities to make diagnoses in a large number of animals, it was soon apparent that a different method would necessarily have to be devised in order to make the desired progress.

PREPARATION OF ANTIGEN

Various organs from rats just dead from surra were tried out in both fresh and preserved states, and the results which were obtained from the fresh suspension of the macerated spleen of a rat just dead from surra were the most promising. In order to establish whether such an antigen would constantly, or at least in most instances, give the results desired, it was repeatedly tested on positive sera of horses affected with dourine, as well as on horse serum known to be free from immune bodies of dourine. After repeated tests on horses clinically affected with dourine had shown the antigen to be uniformly constant in its action, the procedure of diagnosing dourine by this method was definitely adopted. It was at this time that our present method of preparing antigen was first employed, which is as follows:

Gray or white rats are infected with surra by the injection of 0.2 c. c. of blood from a rabbit infected with that disease. Since tests have to be made every day to keep up with the large number of cases submitted and as the antigen proves effective only when prepared fresh, it was arranged that at least two rats should die daily with the disease. When the rats appeared to be at the point of death late in the afternoon it was found that placing such rats in the ice chest until they died furnished a better antigen than when they have died in the cage during the night and have to be used the following morning.

The spleens of the rats are removed, placed in a mortar, and ground up with a small amount of salt solution to a pulpy mass. From time to time more of the salt solution is added, and the suspension thus obtained is filtered twice through a double layer of gauze into a test tube. The quantity of the suspension from each spleen is made up to 40 c. c. by dilution with salt solution.

This suspension constitutes the antigen for the tests of the suspected dourine sera. Dr. Jacob Traum, who was temporarily assigned to this work, found that when the suspension was titered against sera in graduated quantities from a known positive and a known negative case the best results were obtained, and this method has since been adopted. The quantity of antigen employed is double the amount necessary to produce complete fixation with positive serum. The following table gives the method practiced in titrating the antigen:

Table showing method of titration of antigen for the complement-fixation test in dourine.

Tube No.	NaCl solution.[1]	Serum.	Antigen.[2]	Complement.[3]		Hemolytic serum.[4]	Blood corpuscles.[5]	
Positive serum.								
	C. c.	*C. c.*	*C. c.*	*C. c.*		*C. c.*	*C. c.*	
1	2	0.15	0.05	1	For 1 hour in incubator.	1	1	For 1 hour in incubator.
2	2	.15	.1	1		1	1	
3	2	.15	.15	1		1	1	
4	2	.15	.2	1		1	1	
5	2	.15	.25	1		1	1	
6	2	.15	.3	1		1	1	
Negative serum.								
1	2	0.15	0.1	1	For 1 hour in incubator.	1	1	For 1 hour in incubator.
2	2	.15	.2	1		1	1	
3	2	.15	.3	1		1	1	
4	2	.15	.4	1		1	1	
5	2	.15	.5	1		1	1	
6	2	.15	.6	1		1	1	

[1] 0.85 per cent NaCl solution.
[2] Suspension of macerated spleen from rat.
[3] The determined smallest quantity established by titration.
[4] Sensitized rabbit serum.
[5] 5 per cent suspension of red blood corpuscles of sheep.

Half the quantity of antigen which in the negative serum does not inhibit hemolysis, provided this quantity is at least double the amount necessary to produce complete fixation with the positive serum, indicates the titer of the antigen. For instance, if tubes Nos. 1, 2, 3, and 4 of negative serum show complete hemolysis and Nos. 5 and 6 slight inhibition, and at the same time tubes Nos. 6, 5, 4, 3, and 2 of positive serum show complete fixation and No. 1 partial fixation, the quantity of antigen for the test proper would be 0.2 c. c. of the antigen.

Occasionally the antigen does not prove satisfactory for the test and has to be discarded. In these cases the fixation in all tubes is apparently due to the excessive amount of proteids from the spleen. Experience has shown that the excessively large spleens contribute such an antigen. This, of course, is indicated by the titration undertaken prior to the regular test. At other times it was found that the antigen proved satisfactory the following day, after it was allowed to stand in the test tube overnight and the supernatant fluid drawn off for the antigen. This is then retitered and the titer established in accordance with the results of the test.

THE COMPLEMENT-FIXATION TEST

The test proper for the diagnosis of dourine is carried out in a manner similar to that practiced for the diagnosis of glanders.[1]

[1] A more detailed description of the technique of this method as applied to glanders is given by Mohler and Eichhorn in Bulletin 136, Bureau of Animal Industry, entitled "The diagnosis of glanders by complement fixation."

The hemolytic system consists of sensitized rabbit serum, serum from a guinea pig, and a 5 per cent suspension of washed sheep corpuscles.

The serum to be tested is, of course, inactivated for one-half hour at 56° C. and is used in the tests in quantities of 0.15 c. c., since it has been found that fixation in this quantity is obtained only with sera of horses affected with dourine. Tests to determine the smallest quantity of serum of horses having dourine which will give a fixation showed that in several instances even 0.02 c. c. of serum was sufficient to give a complete fixation.

The complement from the guinea pig is always titered previous to the test, as it is absolutely necessary to use the exact amount of the complement to obtain the best results, since a deficiency or an excess of the complement would interfere greatly with the reaction.

In the numerous cases which have been tested the results were almost invariably definite, and only on a very few occasions was it found necessary to make retests on cases which appeared atypical. The reaction is always very marked, and in our work only a complement fixation with the quantity of serum mentioned is recognized as a positive reaction. It is only proper that in the tests the usual number of checks should be employed in order to insure reliable results.

Since the testing has been undertaken by the method described, 8,657 samples have been examined from Montana and the Cheyenne and Standing Rock Indian Reservations in North Dakota and South Dakota. Of these, 1,076 gave positive reactions, which appears to be a very large proportion, but when it is remembered that these animals were kept under range conditions without sanitary or veterinary control and also that before the disease was recognized as dourine it had been diagnosed for a long period as some other affection, it will be apparent that the opportunity for the spread of the disease was ideal.

With the present system of diagnosis, by which even the latent cases can be determined, it is hoped to eradicate the disease quickly. All the horses in the infected localities will be submitted to the complement-fixation test, and by cooperation with the State authorities means will be devised to dispose of the affected animals in such a way as to make the further spread of the disease impossible. The animals which were destroyed as a result of the disease in the above-named localities and which were diagnosed by the complement-fixation test showed in most instances some lesions indicative of the disease. In some of the cases there were no indications of a progressive paralysis, but the lesions existing in the genital organs of either the male or female were sufficient for confirmation of the diagnosis by the complement-fixation test.

It is therefore evident that the diagnosis of trypanosome infections of both man and animal by the complement-fixation test is of very great importance, especially in countries where only one of these protozoan

diseases exists. By this means it is possible to determine all infected persons or animals within a short time and adopt such hygienic measures as would be best suited for the control of the infection. Furthermore, the introduction of a disease like dourine into any country could also be guarded against by a compulsory requirement of this test on all horses imported from countries in which dourine is present.

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THREE UNDESCRIBED HEART-ROTS OF HARDWOOD TREES, ESPECIALLY OF OAK

By W. H. LONG,

Forest Pathologist, Investigations in Forest Pathology, Bureau of Plant Industry

INTRODUCTION

During an investigation made in 1912 of the pathological condition of the oaks in the Ozark National Forest, of Arkansas, and in other sections of the United States the writer found a large percentage of the trees, especially in some regions of Arkansas, attacked by various fungi which rot the heartwood. Twenty different kinds of heart-rots were found. Of this number eight have been previously described and assigned to their causative fungi; two were caused by well-known fungi, but no detailed specific descriptions of the rots have yet been published; one proved to be a true root-rot caused by *Polyporus dryadeus;* three have not yet been connected with their causative organisms; while six have been for the first time definitely associated by the writer with the fungi which produce them. Only three of these last six rots will be discussed in this paper.

INVESTIGATIONS OF HEART-ROTTING FUNGI

The writer found in the Ozark National Forest ideal conditions for the study of heart-rotting fungi, as thousands of white-oak trees (*Quercus alba* L.) were being worked into 36-inch staves for whisky barrels. Trees over 16 inches in diameter were felled and sawed into about 3-foot lengths; these were immediately split into what are known as bolts. As only perfectly sound timber can be used for whisky staves, all rotten, wormy, water-soaked, and stained pieces were rejected and left on the ground where the tree was cut. It was therefore very easy to determine the character and extent of the rot in each tree. As the areas being cut were in a virgin forest, all ages of trees down to about 160 years old (16 inches in diameter) were included. The majority of the trees were cut very close to the ground; the stumps averaged 12 inches in height, but in many cases were much lower. This aided in the investigation, since the nearer the ground the trees were cut the more complete was the record as to the rot in the trunks.

Of the twenty rots found in oak, only the following eight were present to any extent in the trunks and tops of the trees:

(1) A rot which produces hollows caused by *Hydnum erinaceus;* (2) a brown, checked rot caused by *Polyporus sulphureus;* (3) a

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whitish heart-rot, piped in its earliest stages and common in the upper half of the trees, due to *P. dryophilus;* (4) a string and ray rot in the butts of the trees, due to *P. berkeleyi;* (5) a straw-colored rot caused by *P. frondosus;* (6) a white piped or pocketed rot caused by *P. pilotae;* (7) a brown, brittle rot, cause unknown; and (8) a tough, spongy, whitish rot caused by *Fomes lobatus*.

Of these eight rots the bulk of the damage to the timber in the butts of the trees is caused by the following fungi, named in the order of their importance: *Hydnum erinaceus*, *Polyporus pilotae*, *P. sulphureus*, *P. berkeleyi*, and *P. frondosus*. However, *P. dryophilus* causes a most common and very injurious heart-rot of the upper trunk and limbs of oaks in the Ozarks.

Although 64.8 per cent of the felled oak trees studied in the Ozarks were affected with butt-rots, the amount of merchantable timber actually destroyed by these fungi was comparatively small, owing to the fact that these rots do not ascend very high in the trees. More than 2,100 felled oak trees were carefully studied by the writer, and extensive data concerning each tree were recorded. Of the entire number 1,938 were white oaks.

Table I shows the various heights of each rot in the trees down to a certain limit, together with the corresponding stump diameter, the diameter of the rot for each tree, and the number of trees for each recorded rot height. For example, the first line, reading across the page, shows the name of the rot—"hollow-producing rot"; cause—"*Hydnum erinaceus*"; diameter of the stump—"26 inches;" diameter of the rot in the stump—"17 inches"; height of rot in the bole of the tree—"28 feet"; and the number of trees with this height of rot—"1." Where more than one tree has a particular rot of a given height the diameters of the stumps and the diameters of the rot in the stumps are averaged, and the resulting numbers are shown in the proper columns.

TABLE I.—*Data on five types of butt-rots found in white oak (Quercus alba L.).*

Name of rot.	Cause.	Diameter of stump.	Diameter of rot in stump.	Maximum height of rot in butt.	Number of trees having rot of the given height.
		Inches.	*Inches.*	*Feet.*	
Hollow-producing rot	Hydnum erinaceus	26	17	28	1
		40	36	24	1
		30	27	20	3
		25	21	19	1
		29	26	18	2
		26	19	17	1
		29	23	16	2
		32	27	15	3
		26	20	14	4
		28	21	13	3
		28	21	12	10
		30	22	11	2
		27	20	10	13
Pocketed or piped rot	Polyporus pilotae	40	36	24	1
		28	26	20	1
		29	24	16	1
		30	25	15	3
		29	23	14	1
		28	21	12	5
		26	23	10	3
Brown, checked rot	Polyporus sulphureus	29	27	18	1
		33	24	12	2
		36	29	9	1
		26	19	8	4
		26	22	7	4
		28	24	6	19
String and ray rot	Polyporus berkeleyi	38	32	13	1
		30	27	10	1
		28	21	8	2
		28	17	6	3
		27	20	5	2
Straw-colored rot	Polyporus frondosus	29	23	4	2
		25	17	3	3

TABLE I.—*Data on five types of butt-rots found in white oak (Quercus alba L.)*—Contd.

SUMMARY.

Name of rot.	Cause.	Average— Diameter of stump.	Diameter of rot in stump.	Height of rot in butt.	Age of rot.	Total number of trees infected.
		Inches.	*Inches.*	*Feet.*	*Years.*	
Hollow-producing rot.	Hydnum erinaceus	26.0	12.6	3.9	....	648
Pocketed or piped rot.	Polyporus pilotae..	25.6	13.7	3.9	156	408
Brown, checked rot.	Polyporus sulphureus.	25.8	13.6	3.0	....	270
String and ray rot..	Polyporus berkeleyi.	28.0	19.0	3.5	190	57
Straw-colored rot..	Polyporus frondosus.	27.0	14.0	2.3	....	12

In the above summary are given certain data for each of the most important butt-rotting fungi in white oaks, and from them some idea can be obtained as to the amount of damage done by these heart-rotting fungi in the virgin timber of the Ozark National Forest. All of the rots listed in the table are also found in black oak (*Quercus velutina* Lam.), as well as in white oak, but on account of the limited number of trees of this species examined no data are now given for it. All height and diameter measurements given in this article, unless otherwise stated, were taken from the tops of stumps 12 inches high.

In determining the age of the rot only trees were used in which the fungus had undoubtedly entered at an old fire scar long since healed over. The annual rings of wood were counted from the point where the callus had completely closed the wound, so that the heart-rotting fungus must have entered before the wound was covered. Therefore, the figures given here represent the minimum age for each infection. The rot might have entered sooner and therefore be older, but it could not have entered later and therefore be younger, as the callus had closed the wound. No stumps with open wounds of any kind were used in estimating the age of the rot.

The writer realizes that this method of determining the length of time the fungus has been in a tree is open to the following criticism:

(1) The fungus might have entered underground through injuries which reached to the heartwood of the root and thence moved upward into the bole of the tree; (2) the wound made by the fire may have healed above ground, but not below on the stool and roots of the tree, thus

leaving a permanent opening into the heartwood of the trunk just below the surface of the ground. Through such hidden openings the mycelium of any heart-rotting fungus capable of growing in the forest débris could enter the tree, and thus the resultant rot would be directly associated with the old fire scar; (3) some of these heart-rotting fungi may be able to enter through sound, unbroken living roots and then move upward as a heart-rot into the bole of the tree. In this case they would also be true root parasites and not simply mere heart-rotting fungi.

None of the three rots discussed in this article are known to be true root parasites. As to the first objection mentioned, the writer has investigated several hundred uprooted oak stumps, many of which had heart-rot, and in no instance was any evidence found indicating that the heart-rotting fungus entered through the roots and thence worked upward in the tree. On the contrary, repeated instances were found where the rot began at the surface of the ground in an old fire scar or other wound and moved downward in the heartwood of the root and upward in the bole of the tree. In every case where the rot had entered the roots it had evidently come from above and not from below, as the rot was limited to the heartwood of the root, while the sapwood was alive and sound. However, there is a large wood borer which lives in the roots of oaks, and when its burrows reach the surface of the roots an opening would be made for any fungi to enter from the soil. It is well known that in the roots of oaks the amount of heartwood compared to that of sapwood is very small. This in itself makes improbable the entrance of heart-rotting fungi through the roots, especially sound ones.

In regard to the second objection mentioned, the writer has recently examined more than 200 oak trees with fire-scarred bases, and not a single one was found in which the wounds having healed above ground had not also completely healed over below the ground. As a rule, forest fires injure the tree but a short distance, 2 to 3 inches, below the collar of the tree, owing to the protection of the soil. Therefore, it is not impossible for these three heart-rotting fungi to enter through the root system; but taking the above facts into consideration it is improbable that they did enter by this route, even granting that they are capable of leading a purely saprophytic existence in the soil and forest débris—a condition yet to be proved.

The very close association of the heart-rots with the old fire scars in the trees studied is so evident that undoubtedly the causal fungi entered the tree by this route. So marked is this association of fire scars with heart-rots in the Ozarks that one could tell the areas in the forest which had been most frequently burned over from the percentage of trees affected with heart-rots.

The writer has found three types of heart-rotting fungi in living trees: (1) Those limited to the base and lower portion or butt of the tree, for example, *Polyporus berkeleyi* and *P. frondosus;* (2) those which are able

to enter either at the butt or in the top of the tree, such as *Hydnum erinaceus*, *Polyporus sulphureus*, and *P. pilotae;* (3) those which enter the upper portion of the tree and work in both directions from the point of entrance, but rarely, if at all, enter through fire scars at the butt, such as *P. dryophilus* and *Fomes everhartii*.

THREE UNDESCRIBED TYPES OF HEART-ROTS

In a later article the writer expects to discuss a large number of heart-rots of the oak, limiting this paper to a detailed description of the following rots: A pocketed or piped rot of the oak, chestnut, and chinquapin caused by *Polyporus pilotae;* a string and ray rot of the oak caused by *P. berkeleyi;* and a straw-colored rot of oak caused by *P. frondosus*.

A POCKETED OR PIPED ROT CAUSED BY POLYPORUS PILOTAE

The rot produced by *P. pilotae* has been found by the writer directly associated with the sporophores of this fungus in the following species of trees: *Quercus alba* L., *Q. velutina* Lam., *Q. texana* Buckl., *Q. coccinea* Muenchh., *Castanea pumila* (L.) Mill., and *C. dentata* (Marsh) Borkh.

A Pocketed or Piped Rot in White Oak

The description of the pocketed or piped rot which follows was made from the diseased wood of a white-oak tree (*Quercus alba*) which was cut on July 23, and on August 27 the sporophores of *Polyporus pilotae* shown in Plate VII, figure 1, were found fully developed on the end of the log. There could be no question as to the identity of the fungus producing the rot in this case, as less than 30 days had intervened between the felling of the living tree and the formation of the sporophore of *P. pilotae*.

The first indication of this rot in white oak is a slight browning of the heartwood. Later white, oval, or circular cellulose patches from delignification appear in this discolored wood. These white areas by dissolution of the fibers often become holes, which show in both radial and cross section (Pl. VII, fig. 2). The delignification seems to originate in the last layers of the summer-wood fibers and spreads in a very irregular manner. In later stages long strings of white cellulose fibers are found. This is especially true where an abundance of air and rain water can reach the rotting area, especially in old dead logs or in trees with cracks or in hollow, open butts. The delignification and absorption of the fibers do not follow the spring wood as closely as they do in the scarlet oak (*Quercus coccinea*).

Another type of cavity may be formed which seen in radial view is 0.5 to 1 mm. by 1 to 2 mm. in size. These cavities are lined with the ends of the white cellulose fibers and usually occur in and at right angles to the large spring vessels, but they may also extend radially from one annual ring to the next in a more or less winding or interrupted course.

Under the microscope the large, thick-walled, colorless hyphæ are plainly seen in these holes, and to them the holes undoubtedly owe their origin. The edges of the perforated vessels as well as the adjacent cells have been delignified. This type of cavity was especially abundant in the wood immediately adjacent to the sporophore.

The final stage of this rot in white oak seems to present one of two conditions: If an abundance of air and water is present, all the wood fibers will be changed to cellulose, then dissolved, leaving a very light, brittle, rotted wood of a dark-brown color, which later gradually crumbles into a dirtlike mass. This is the type of rot usually found in dead trees or living trees with hollow, open butts. If, on the other hand, only a limited amount of air and no rain water is present, as is the case in living trees with no open wounds reaching to the diseased heartwood, the rotting wood may become honeycombed with empty, cellulose-lined, elliptical cavities (Pl. VII, fig. 3) or it may decompose into a fibrous mass consisting of long, white cellulose strands and partially decomposed vessels and medullary rays. Large quantities of these white cellulose strands are often found in the butts of freshly cut trees which externally appear perfectly sound but have this rot in the heartwood.

A Pocketed or Piped Rot in Scarlet Oak

The following description of the pocketed or piped rot was made from a wind-thrown scarlet oak (*Quercus coccinea*), which on falling split on the upper side for 7 or 8 feet. From this fissure a sporophore of *Polyporus pilotae* protruded. The rot began in the top of the tree and had reached the ground. The tree was sawed into 6-foot lengths and split open on March 5, and on May 30 fresh sporophores were beginning to form on the ends of the split pieces.

In this host the fungus first attacks the spring wood immediately around the larger vessels, turning it to a light-tan color. This change in color is accompanied by the absorption, more or less irregularly, of the cells of the spring wood, while the wood fibers intermixed with these cells are delignified from within outward. The tan color of the affected areas is due to the walls of the wood fiber and other cells adjacent to the vessels turning a golden yellow. At this stage of the rot the spring wood is badly decomposed and consists of cells and vessels much eroded, leaving fragments of both intermixed with apparently unchanged cells and vessels. This partial destruction of the spring wood causes it to separate readily into circular sheets along these lines of weakness.

The next stage of the rot going inward toward the center of the tree is the almost complete change of the summer-wood fibers and tracheids into a yellowish white cellulose. Under the microscope the rotten wood is seen to consist of delignified wood fibers intermixed with the remnants of the spring wood and of nearly unchanged medullary rays, while the entire mass of rotted wood is ramified by large, colorless, thick-walled,

much-branched fungus hyphæ 5 to 10μ in diameter. These hyphæ are especially abundant in the spring wood. In this stage the rotten wood easily pulls loose in thin flakes, the line of cleavage being between the medullary rays. Many white and yellowish white unabsorbed cellulose wood fibers are found in the rot at this stage.

The third and final stage of the rot is found in the center of the tree and is of a reddish brown color, there being a rather sharp line of demarcation between this and the light-tan color of the second stage. In this last stage there are found remnants of the vessels, a few unabsorbed fiber tracheids, wood fibers, and partially decomposed medullary rays intermixed with the colorless hyphæ of the fungus. Not enough hyphæ are present, however, to bind the rotted wood into a tough mass. The wood at this stage at first is rather brittle when dry and can be partially crushed into fragments between the fingers, but finally it crumbles into a brownish dirtlike mass, which remains in a cavity thus formed inside the tree, unless removed by squirrels, etc. On the split surface of the rotting wood which was exposed directly to the air and rain water a dark, reddish brown mycelial layer of a gelatinous nature was found. This gelatinous mass might, of course, be a foreign growth and not a part of the mycelium of the fungus *Polyporus pilotae*. The reddish cast is due to the formation of reddish brown bodies on or among the hyphæ; sometimes several of them form a conidialike chain.

In general, the delignification seems to begin in the layer of wood fibers forming the boundary line between the summer growth and the spring layer of wood formed the following year and spreads most rapidly in the spring wood, leaving more or less intact the largest vessels and the cells immediately adjacent. At this stage many of the medullary rays contain a chestnut-brown, humuslike substance.

A Pocketed or Piped Rot in the Texan Oak

The rotted wood from which the following description was made was obtained from an old log of Texan oak (*Quercus texana*), just beneath a very large sporophore of *Polyporus pilotae*.

The rot in this host is much like that described for the scarlet oak, consisting of long strands of white to creamy white, cellulose fibers interspersed with the partially changed spring wood and medullary rays. There is a zone of one-fourth to one-half inch of discolored wood between the sound wood and the zone where the delignification is evident.

A Pocketed or Piped Rot in Chinquapin

This description of the pocketed or piped rot was made from material obtained from a fallen log of chinquapin (*Castanea pumila*) on which a sporophore of *Polyporus pilotae* was found. The rot was seen a number of times in fallen chinquapin trees in the Ozark National Forest. In

living trees of this species, as in the white oak, the rot may vary somewhat.

In the chinquapin the fungus first delignifies the latest formed summer-wood fibers, those immediately adjacent to the large vessels, and spreads finally to all the wood fibers lying between the spring wood of any two successive years. As the summer wood is composed largely of wood fibers, the ultimate result is an almost complete separation of the layers of spring wood. The concentric layers of the spring wood are separated at first by the white to yellowish white, cellulose fibers. Later this cellulose is entirely absorbed, leaving only the concentric layers of the spring wood loosely held together by the remnants of the wood fibers and the few small vessels found in the summer wood (Pl. VII, figs. 4, *a*, and 4, *b*). The vessels and other cells of the spring wood have in the meantime become more or less corroded and have assumed a reddish brown color. In the final stage of the rot the wood when dry is brittle and can be easily broken between the fingers. In old, weathered chinquapin logs attacked by this fungus the rot is very characteristic, consisting of concentric layers of rotten wood which are so loosely held together that one can easily pull off layer after layer.

A Pocketed or Piped Rot in Chestnut

The material examined for the following description of the pocketed rot was obtained from the diseased wood of living chestnut trees (*Castanea dentata*) located near New Berlin, N. Y. In the hollow butts of these trees the resupinate form of *Polyporus pilotae* was found. Some trees were examined which had recently been made into railroad ties. Ample opportunity was thus given for a thorough study of the various stages of the rot in different regions of the tree trunks.

The first indication of the rot is a watery brownish discoloration of the heartwood. In cross section this discolored area or "soak" often appears as a central circular patch (Pl. VII, fig. 5), often flanked by one or more very narrow crescent-shaped discolored areas, lying between the diseased portion and the sapwood, or sometimes the "soak" may be eccentrically placed in the heartwood of the tree. These rings of diseased wood follow very closely certain annual rings and usually appear first in the immediate vicinity of the large spring vessels. Sometimes only one annual ring will show the disease, and this may extend for several feet longitudinally in the tree beyond that portion of the rot where delignification is evident.

The mycelium of the fungus travels much more rapidly longitudinally in the tree than radially. It is first seen in the large spring vessels. The adjacent wood fibers soon show signs of delignification, which usually occurs most abundantly in the latest formed summer wood, where small, irregular, oval patches of cellulose are produced. These patches usually lie opposite the largest vessels and immediately adjacent to them. This association of cellulose and large vessels is especially noticeable in cross

section, where the delignified areas may usually be seen in the summer wood. The delignification may continue without much absorption of the cellulose till long white bands of cellulose are found lying alongside of the vessels. This formation of bands of cellulose is especially marked when an abundance of air and rain water can penetrate the rotting wood. Such a condition obtains in fallen logs with large hollows or cracks in them.

If, on the other hand, the rot is in the center of the heartwood of a living tree, the small, oval-shaped cellulose patches increase in size, hyphæ from the adjacent vessels gradually absorb the cellulose until lens-shaped cavities are formed which at first are filled by a dense growth of rather coarse hyaline hyphæ. The sides of these cavities are lined with the projecting ends of the delignified wood fibers much like the rot produced by *Trametes pini*. Later both the hyphæ and the cellulose lining may disappear and leave an empty cavity, thus producing a pocketed or honeycomb type of rot.

In the earlier stages of the rot the diseased heartwood surrounding the white cellulose patches is of a cinnamon color. The wood at this stage of the rot is rather firm, contains small cellulose patches (Pl. VII, fig. 6), and has vessels filled with colorless hyphæ from 6 to 10μ, or even less, in diameter. The white, cellulose, oval areas gradually encroach upon the summer wood till they extend from one annual layer of vessels to the next. By this time much of the cellulose has been absorbed, and small, distinct cavities are formed. At this stage of the rot the diseased wood is much lighter in weight and can easily be broken into pieces between the fingers. Finally, a condition is reached in which the reddish brown rotten wood is very loosely held together and tends to split up into concentric sheets corresponding to the annual rings. Short oval holes running radially through two or three annual layers of wood are also common at this stage. In rare cases the cells surrounding the vessels are completely absorbed, while the summer-wood fibers are delignified without the formation of cavities. Many of the trees attacked by this fungus had hollows in them, but whether the hollow was caused by this fungus or by a subsequent attack of another fungus, as *Hydnum erinaceus*, could not be determined. While this rot is a butt rot of the chestnut, it is also able to enter through dead limbs and thus produce a top rot. The rot when it enters by means of a dead branch follows the heartwood of the branch down to its juncture with the heartwood of the tree. The fungus then travels both upward and downward in the bole of the tree (Pl. VIII, fig. 1).

Of the chestnut trees in the region examined around New Berlin, N. Y., fully 75 per cent had tops attacked by this fungus. This large percentage was probably due to numerous dead limbs on each tree, thus affording the fungus ample opportunity to enter the tops. Of 302 felled chestnut trees which were studied by the writer in this region 119, or 39.4 per cent, had this rot in the butts. This large percentage of infection

was mainly due to the fact that practically all of the trees came from a coppice growth, and if the original stump was diseased, the later generation of trees springing from its base were also infected through their union with the old diseased stump. Officials of the Unadilla Railroad claim that chestnut ties having only a small amount of this rot in their centers last only three to five years when placed in their roadbed.

This rot in the chestnut is apparently identical with the piped rot of chestnut described by Von Schrenk and Spaulding.[1] Their description of the piped rot of the oak in the same publication apparently includes two distinct rots; viz, this rot caused by *Polyporus pilotae* and the common heart-rot of the oak caused by *Polyporus dryophilus*,[2] which is also a piped rot in one of its stages and will be described in a later publication.

Results of Investigations of the Pocketed or Piped Rot

The most common and constant characters of this rot, taking all the hosts into consideration, are the presence of long, continuous strands of cellulose, the delignified wood fibers and fiber tracheids, and the white-lined pockets so common in the living oak and chestnut in the early stages of the rot. In the white oak the changing of the wood fibers into cellulose is not so complete as in the other hosts, so that the wood is not broken down as much. In both white oak and chestnut there are holes which run tangential to the tree through the spring wood or radially from one annual ring to another. This condition is especially noticeable in the older stages of the rot in the butt of the trees and in the vicinity of freshly formed sporophores of the fungus.

Sporophores of *Polyporus pilotae* were formed on living white oaks, on the ends of white-oak logs cut only one month, on old logs which evidently had been cut for several years, on a standing fire-killed yellow oak (*Quercus velutina*), on a fallen and very rotten log of Texan oak (*Q. texana*), on the trunk of a wind-thrown scarlet oak (*Q. coccinea*), on old dead logs of chinquapin (*Castanea pumila*), on the inside of a hollow in a living chinquapin tree, and on chestnut trees (*C. dentata*). In the last instance the sporophores were resupinate and growing in the hollow butts of the living trees. Of the 302 chestnut trees studied in New York 119 had this rot. The average diameter of the rot per tree was 6.5 inches, the average diameter of the stump 16.6 inches, and the average height of the rot per tree was 5.4 feet. The maximum diameter and height of the rot in any one tree was found in a tree 27 inches in diameter. The diameter of the rot in this tree was 20 inches and the height of the rot was 20 feet.

[1] Schrenk, Hermann von, and Spaulding, Perley. Diseases of Deciduous Forest Trees. Bur. Plant Indus., U. S. Dept. Agr., Bul. 149, p. 39, 1909.

[2] Hedgcock, George G. Notes on some diseases of trees in our national forests. Phytopathology, v. 2, no. 2, p. 73, 74, Apr., 1912.

A comparison of the average height of this rot in the chestnut (5.4 feet) with its average height in the white oak (3.9 feet) shows that it extends higher up the bole in chestnut than it does in white oak. This difference is still further accentuated by the difference between the average diameter of the diseased chestnut trees (16.6 inches) and that of the diseased white oak (25.6 inches). The average age of the chestnut was probably not over 100 years, while that of the white oak was about 250 years. The very large and numerous vessels in the chestnut made it possible for the fungus to travel to greater heights in this wood in a given time than it could in the white oak, which is a much denser, slower growing wood. Of course, the amount of rainfall and other environmental factors would have to be taken into consideration when comparing the relative heights of this rot in the chestnut and oak.

On the same area in New York where the chestnut mentioned above was studied, a record was made of 477 felled white oaks. Of this number only 4, or less than 1 per cent, had the piped rot so common in the chestnut. Its average height in these 4 trees was 3 feet, its average diameter was 8 inches, and the average diameter of the affected trees was 15 inches. This small percentage of infection was probably due to the fact that no fires had been allowed in these woods and therefore practically no opening into the heartwood of the trees was offered and to the further fact that the oaks did not originate from a coppice growth.

On an area in Virginia which had been in timber for about 60 years the writer checked the stumps of 565 chestnut trees which had been recently cut. The majority of these trees originated from sprouts and had made a vigorous growth, the average age of the trees being about 50 years. Of the 565 chestnut trees only 18, or 3 per cent, had piped rot in the butts. Of this same area 201 white-oak stumps were also checked, of which number 13, or 6 per cent, had piped rot in the butts. This area was an old abandoned field which had been used as a pasture for many years and, so far as the writer could ascertain, had not been burned over in 50 years.

The rate of growth of the various rots in individual trees, as shown by the records made in the Ozarks, varies greatly. For instance, *Polyporus sulphureus* had been in one white oak 200 years and had made a growth in height of only 6 inches during that time, while the same fungus had been in another white oak for 50 years and had made a growth in height during that time of 3 feet. A similar wide range in growth is found for the rot produced by *P. pilotae* in white oak, where it was in one tree for 280 years and had made a growth in height of only 6 inches, while in another white oak the same fungus had made a growth of 4 feet in only 60 years. However, taking into consideration the average and maximum height of each of these rots and their average rate of growth in a tree, it is evident that they do not grow with any thing like the rapidity—at least in white oak—that might be expected.

Of the 1,938 white oaks studied in the Ozarks 408 trees had this rot. The average diameter of the rot per tree was 13.7 inches, the average diameter of the stump was 25.6 inches, and the average height was 3.86 feet. The maximum diameter and height of the rot in these trees was found in a tree 400 years old. The diameter of the tree was 40 inches, the diameter of the rot was 36 inches, and the height of the rot was 24 feet. The oldest rot was 280 years and was found in a tree 310 years old. The average age of the rot in 92 trees was 156 years. The average rate of growth of the rot was 1 foot in height and 3.5 inches in diameter for every 40 years of time. The youngest white oak found with this rot was 180 and the oldest 400 years old.

The exact range of this fungus is not known. It is very common in oak and chinquapin in the Ozark National Forest and has been found in Virginia on scarlet oak.

The writer has also examined authentic sporophores of this fungus on the following hosts and from the following localities:

"On underside of log" (resupinate sporophore), Pennsylvania; "on log," North Carolina; "in hollow oak log," Ohio; "on rotten oak log," Indiana; "on underside of old log" (resupinate sporophore), West Virginia; "on dead oak logs," New York; "on oak," North Carolina; from Iowa, no host given; "on punky chestnut log," no locality given; from Florida, no host given; from South Carolina, no host given; from Tennessee, no host given; "on end of log," Canada; "on oak," Canada; "on old logs," Canada. Three specimens were also seen from Europe, where it is known as *Polyporus croceus* (Pers.) Fries: "On living oak," Sweden; "on old oak and chestnut," apparently from France, no locality given; and "on old oak," locality not given. It probably occurs east of the Rocky Mountains in the United States on oak, chinquapin, and chestnut wherever the hosts grow and also in Europe on oak and chestnut. It is by far the worst heart-rot found in chestnut timber, occurring in this host as both a butt and top rot. It stands second in destructiveness to white-oak timber in the Ozark National Forest, both as to number of trees infected and height attained in the tree. *Hydnum erinaceus* is the most destructive heart-rotting fungus of the oak found in the Ozark forests (see Table I, p. 111). The rot caused by *P. pilotae* was found associated with the rot produced by *Hydnum erinaceus* in 105 trees, with string and ray rot in 3 trees, with *Polyporus sulphureus* rot in 8 trees, and with both *Hydnum erinaceus* and *Polyporus sulphureus* rots in 5 trees.

The sporophores of *P. pilotae* were in an actively growing stage during the month of September in the Ozark National Forest. This fungus usually enters the oak at the base of the tree, probably through fire scars in most instances. The rot was also found occasionally in the upper part of the tree, while the base was not infected. The fungus,

therefore, can enter the tree through fire scars in the butt and also through broken branches or other wounds on the bole and in the top of the tree. There is also a honeycomb rot in oak and in chestnut caused by a species of Stereum. This honeycomb rot in its earlier stages resembles so closely certain stages of the rot caused by *P. pilotae* that it is very difficult to determine which fungus produced the rot, unless the sporophores are present.

A STRING AND RAY ROT OF OAKS CAUSED BY POLYPORUS BERKELEYI

The initial stage of the string and ray rot in the white oak when seen in a radial longitudinal section is characterized by the presence of large amounts of cellulose tissue, causing the rotted wood to have a yellowish white appearance. This stage of the rot may extend for 4 to 8 inches longitudinally, when it terminates rather abruptly in apparently sound wood. The cellulose tissue is composed exclusively of delignified wood fibers, which constitute the bulk of the summer wood. The middle lamellæ have entirely disappeared, so that each delignified wood fiber is separate from its neighbor.

The next stage of the rot is the rather rapid and complete absorption of these delignified fibers, leaving both the spring and summer vessels, the cells immediately adjacent, and the medullary rays intact. The rot at this stage is most characteristic, consisting of a rather dry mass of medullary rays interwoven with long, flat strings of wood (Pl. VIII, fig. 2). These strings are sometimes 8 to 10 inches long by one-sixteenth of an inch wide and consist of the vessels held together by the unabsorbed adjacent cells. The rot in this stage is reddish brown and on account of its peculiar and characteristic structure has been named the "string and ray rot" by the writer. This second stage of the rot may extend from a few inches to several feet up the tree. At first the flattened strings of wood are rather tough, but this gives place to a condition in which the strings get brittle and can be crumbled between the fingers into a brownish, coarse powder. Finally the entire mass of rotting wood becomes overrun with a colorless mycelium. In this condition the rot is very moist, almost wet, and consists of fragments of vessels and of the medullary rays, interwoven with the colorless hyphæ of the fungus. It can now be compressed with the hands into rather firm balls which may be thrown with force and yet will not break into pieces.

Finally the entire mass of rotted wood and mycelium gradually disappears till a hollow is left in the base of the tree. Over the surface of this vanishing mass brittle white or creamy white layers of mycelium are formed, on the undersides of which are cottony masses. Shakes, checks, or worm holes in the wood may have a slight mycelial felt in them.

The string and ray rot seems to be one of the very few heart-rots of the white oak capable of the complete absorption of the heartwood of the tree, thereby producing hollows. The slow rate of travel upward in the

tree compared to its radial rate of growth and the subsequent rather complete absorption of the entire heartwood in the stool of the tree produce a peculiar condition when the tree is cut. A tree in which this rot has reached its last stages in the stool will be rotted to or nearly to the sapwood for 1 to 3 feet from the ground, and such a tree will fall as soon as the thin shell of sound wood is severed, carrying with it the partially rotted heartwood, which easily pulls loose from the badly rotted mass in the stool. The butt end of the felled tree will then have attached to it a cylinder of rotted wood some 1 to 2 feet long in the string and ray stage, thereby leaving a hollow stump in the bottom of which there will be the wet, very rotten mass of wood held together by the threads of mycelium.

This rot has a very strong but pleasant odor, somewhat like that of anise oil. This odor disappears after the exposure of the rot to the air for several weeks, but is so marked when the tree is first cut that it can be detected at a distance of from 20 to 30 feet.

Studies were made of 1,938 white-oak trees which were cut for staves. Of these, 57 had this rot. The average diameter of the rot in these 57 trees was 19 inches; the average height per tree was 3.5 feet; and the average age per tree was 280 years. The maximum diameter and height for this rot in any one tree were found in a tree 380 years old. The diameter of the rot was 32 inches and the height was 13 feet. As a rule, this rot does not extend very high in a tree, as compared to its extent in diameter, and ends very abruptly in perfectly sound wood. It was also found in the butts of two black oaks (*Quercus velutina*); the sporophores of the fungus were seen several times on the roots of both white and black oaks which had not been felled. The writer repeatedly found from one to three sporophores of *Polyporus berkeleyi* (Pl. VIII, fig. 3) attached to the roots of the trees in which this characteristic heart-rot was present. The direct connection of the rot in the stump with the sporophore could easily be traced by following the rot down into the stool and thence through the rotted heartwood of the root to the sporophore. This was done in the case of at least a dozen trees.

The youngest tree found with this rot was 170, the oldest 500 years of age. The rot was usually found in mature and overmature trees from 25 to 32 inches in diameter which grew in rich soil on north slopes. In 6 of the stumps of the 57 white oaks found affected with this rot some evidence as to the age of the rot was obtained. The oldest rot was 380 years and was found in a tree 420 years of age. The average age of the rot in these six trees was 190 years. The average rate of growth of the rot was 1 foot in height and 5.4 inches in diameter for every 60 years of age. The fungus producing this rot usually enters the tree through some wound at the butt, such as fire scars. No evidence was found that it could enter through broken branches. In no instance was the

rot found in the top of a tree. It originates at the butt and travels upward in the heartwood of the tree.

Of the sporophores of *Polyporus berkeleyi* found by the writer all occurred at the base of oak trees, either plainly growing from the exposed root or on the ground near the base of the tree. In the latter case a careful examination of the basal portion of the sporophore showed that it was attached to the roots of the tree. The writer has never found it growing on the bole of the tree above the surface of the ground, though it is not impossible that it could grow as brackets on the trunk, but it is doubtful if it does. *P. sulphureus* Fr. and *P. schweinitzii* Fr., two closely related polypores which produce heart-rots in living trees, are often found growing on the roots at the base of the diseased trees as well as on the boles proper.

There was no evidence to indicate that the fungus could fruit on the trunk after the trees were felled, even if the rot should continue to grow in the felled tree. A small sporophore was found at the base of a 20-foot white-oak snag, while a large sporophore was found at the base of a dead standing white oak, indicating that the fungus could continue to grow and fruit after the trees were dead. The only external evidence that trees are attacked by this heart-rot is the presence of the sporophores of the fungus on the roots. Sometimes the base of the diseased tree is slightly "swell butted." This last character, however, is common to trees attacked by other butt-rots.

This rot was found associated with the rot produced by *Hydnum erinaceus* in 7 trees, with the pocket rot caused by *Polyporus pilotae* in 3 trees, and with the rot produced by *P. sulphureus* in 1 tree. *Hydnum erinaceus* was repeatedly found attacking and completely destroying wood previously rotted by the following fungi: *Polyporus berkeleyi*, *P. pilotae*, *Fomes everhartii*, *Polyporus hispidus*, *P. frondosus*, and *P. dryophilus*, but no evidence was found of its attacking the rot produced by *P. sulphureus*, although it was found associated with this rot in the same tree. Fresh sporophores of *P. berkeleyi* were common during the latter part of August and probably could be found during September. No fresh sporophores were seen in December.

The writer has also examined authentic material of *Polyporus berkeleyi* on the following hosts and from the following localities: "At base of white oak," Canada; "on roots of living white oak," Missouri; from New York, West Virginia, and Missouri no host was given; "from dead place near ground in living oak," Pennsylvania; "on base of stump," North Carolina; "on oak," New York; "on chestnut," New York; "at base of tree," Ohio; "at base of ash stump," Ohio; "at base of oak stump," Pennsylvania; from West Virginia, Pennsylvania, Ohio, North Carolina, and Canada no host was given; "near roots of large oak," Canada; and "under oak," Massachusetts. Apparently this fungus is found only in America. The writer has never seen it growing on anything but oak,

but from the above record it also occurs on chestnut and on ash, while Dr. Weir, of the Office of Investigations in Forest Pathology, reports it on larch in 1913.

From the studies made in the field the writer finds no proof of the ability of this fungus to grow permanently as a saprophyte in humus and decayed forest litter. All sporophores seen certainly grew from mycelium inside the living, diseased trees at whose base they were found and not from mycelium ramifying in and drawing nourishment from the soil or leaf litter.

Weir reports[1] the finding of sporophores of *Polyporus berkeleyi* attached to the roots of the larch in Montana, but from observations made in that region reached the conclusion that the mycelium ramified in the deep forest litter and drew its food from that source as well as from the rotten roots to which the sporophores were attached. It will prove very interesting if this rot in the larch should prove to be similar to that produced by this fungus in the oak, especially since the anatomical character of the wood of these trees is so different.

A STRAW-COLORED ROT OF OAKS CAUSED BY POLYPORUS FRONDOSUS

The initial stage of the straw-colored rot of the white oak (*Quercus alba*) is characterized by the dissolution of the middle lamellæ and the delignification of some of the wood fibers, leaving the fibers now consisting of cellulose free from each other. (Pl. VIII, fig. 4.) The advancing line of the rot upward in the tree consists of irregular, rather indefinite white patches, conforming more or less in size and shape to the largest medullary rays, or of narrow white bands projecting into the sound wood. Five or six inches below the boundary line between the advancing rot and sound wood the color in radial sections is more evenly white, as the patches have coalesced more or less at this stage. The unpolished split surface feels velvety, owing to numerous projecting free ends of the cellulose fibers. A tangential view of the advancing line of rot shows a whitish surface consisting of white delignified fibers interspersed with unchanged medullary rays and unchanged or only partially delignified vessels and their immediate adjacent tissue. In cross section the rot has a whitish cast surrounded by the natural color of sound heartwood.

The amount of delignified tissues in the earlier stages of this rot is much less than that found in the earlier stages of the string and ray rot. Eight to twelve inches behind the advancing point of the rot numerous colorless hyphæ are found in the larger vessels. At this stage in the rot some of the delignified tissue has been entirely absorbed. The delignification and absorption begin with the inner layer of the wood fibers and proceed centrifugally, so that the lumen of the cell

[1] Weir, J. R. Some observations on Polyporus berkeleyi. Phytopathology, v. 3, no. 2, p. 101–103, pl. 9, 1913.

gradually increases in size as the rot progresses. Marked delignification occurs in the tracheids and cells immediately adjacent to the larger vessels in which the fungous hyphæ are found, but the medullary rays and walls of the large vessels are still strongly lignified, as are also the numerous tyloses seen in these vessels. The walls of the tyloses were punctured in many places by the fungous hyphæ. Six to eight inches farther down, or 18 to 24 inches behind the advancing line of the rot, the rotted wood is soft and spongy to the touch and is of a straw color. In this stage the rotted wood consists of partially changed medullary rays, some unchanged wood fibers, and vessels with fragments of these in various stages of absorption, all strongly permeated with fungous hyphæ. Some medullary rays are still intact, while others have their outer radial cells either partially or entirely delignified and absorbed, so that in pulling apart the rotted wood tangentially, the medullary rays often pull out, leaving holes in one piece similar in size and shape to the rays, while the rays themselves remain attached to the other piece of the rotted wood.

The final stage of the rot differs but little from this condition, since there are still portions of all the elements present either unchanged or only partially changed. The rotted wood is rather tough and can be bent and twisted without breaking if taken in pieces 12 to 18 inches long and 4 or 6 inches thick. It is rather soft and spongy, but the fungus apparently never completely disorganizes the wood, thereby producing hollows. On weathering for two or three months the rot in the tops of the stumps and in the ends of the rejected butt cuts turns reddish brown and becomes firmly agglutinated, a condition so characteristic of this rot that one could identify the rot by this feature alone, without the presence of sporophores.

The rot has no odor. A section through the reddish discolored wood shows an abundance of light-brown hyphæ. The remnants of the remaining lignified tissues are also colored light brown. In a freshly cut stump which had this rot it would be hard to identify the rot in a cross section. Even when the wood is split open, there are no very pronounced macroscopic characters to distinguish it, like the string and ray stage of the rot caused by *Polyporus berkeleyi*.

The following is a brief description of the gross appearance of this rot caused by *Polyporus frondosus*, made as soon as the tree was cut.

The rot seen in a radial longitudinal view consisted of long white lines advancing 6 to 10 inches beyond the more completely rotted wood below. These lines apparently were caused by the fungous hyphæ following the vessels in certain annual rings. There was a watery reddish discoloration or "soak" about 2 inches in advance of the white lines. The older rot was of a light-tan or straw color and with a slight mycelial weft in checks. Some 2 to 6 inches below the upper end of the white lines, white downy masses of mycelium could be seen by the aid of a hand lens in the large spring vessels situated in the white lines. In cross section the rot had a

coarse, fibrous surface, due to the stiff unabsorbed ends of the vessels, partially isolated by the absorption of the wood fibers and the subsequent tearing apart by the saw when the tree was felled. This fibrous character was not evident except where the tree was sawed.

This rot was identified in only 12 trees out of the 1,968 white oaks examined. No idea was obtained as to its age in a tree, as all of the trees found affected by it had open scars at their bases. It was apparently through such scars that the fungus entered the tree. Sporophores of *Polyporus frondosus* were found attached to the roots of 6 of the trees in much the same manner as those of *P. berkeleyi*, usually on that side of the tree which had the fire scar. The average height in the 12 trees attacked was 2.3 feet, the average diameter of the rot 12 inches from the ground was 14 inches, and the average age of the trees attacked was 270 years. The minimum age of the trees attacked was 220 years and the maximum age was 340 years. The maximum diameter of the rot in a tree was 24 inches and the maximum height in the tree was 4 feet.

The only external evidence of this rot in a tree was the presence of the sporophores attached to the roots of the diseased tree. The connection between the attached sporophores and the heart-rot in the tree was easily established in every case. This fungus may not continue to grow in the diseased trees after they are cut, for no sporophores have been found on felled trees nor have any been reported as occurring on logs. It seems to be strictly a butt-rot, as no evidence is known to the writer of its occurrence in the tops or on the branches of trees. One tree was found in which this rot was associated with the rot produced by *Hydnum erinaceus*. The writer has also found sporophores of *P. frondosus* on the roots of *Quercus digitata* at Arlington, Va., and has examined authentic herbarium material of the plant on the following hosts and from the following localities: "In evergreen woods," Canada; "under oak," Massachusettes; "at base of oak," Massachusetts; "at base of red oak," New York; from Ohio, no host given; "on old stump," Ohio; "at roots of fallen oak," Ohio; "at roots of oak," Maryland; "on dead trunks, '*Aceris negri*,'" Missouri; "on roots of chestnut," Germany; "on roots of chestnut," Italy; "on *Castanea vesca*," France; "at base of large oaks," Saxony; "at base of trunk," Italy; and "on roots of chestnut," Bohemia (?).

This fungus, which has been known to mycologists for many years, is represented in nearly all the more complete lists of European fungi. It is evidently very widely distributed, inhabiting frondose woods in North America and Europe, in direct association with oak and chestnut trees.

The writer is under many obligations to the officers in charge of the New York Botanical Garden for the many courtesies extended to him while there, and to Dr. W. G. Farlow for free access to the Cryptogamic Herbarium of Harvard University.

DESCRIPTION OF PLATES

PLATE VII. Fig. 1.—*Polyporus pilotae:* A sporophore on the end of a white-oak log from Arkansas. Photograph made 43 days after tree was felled.

Fig. 2.—*Polyporus pilotae:* Rot appearing in the butt of a white-oak log from Arkansas, showing the holes and white cellulose areas characteristic of this rot in a cross section of a living oak.

Fig. 3.—*Polyporus pilotae:* Radial-longitudinal view of a white-oak log from Arkansas, showing the honeycomb type of the rot with the white cellulose lines and elliptical hollows.

Fig. 4.—*Polyporus pilotae:* Rot occurring in a log of *Castanea pumila* from Arkansas; *A*, concentric layers of the rotted wood; *B*, white cellulose fibers.

Fig. 5.—*Polyporus pilotae:* Cross section of a chestnut log from New York, showing the central circular rotted zone.

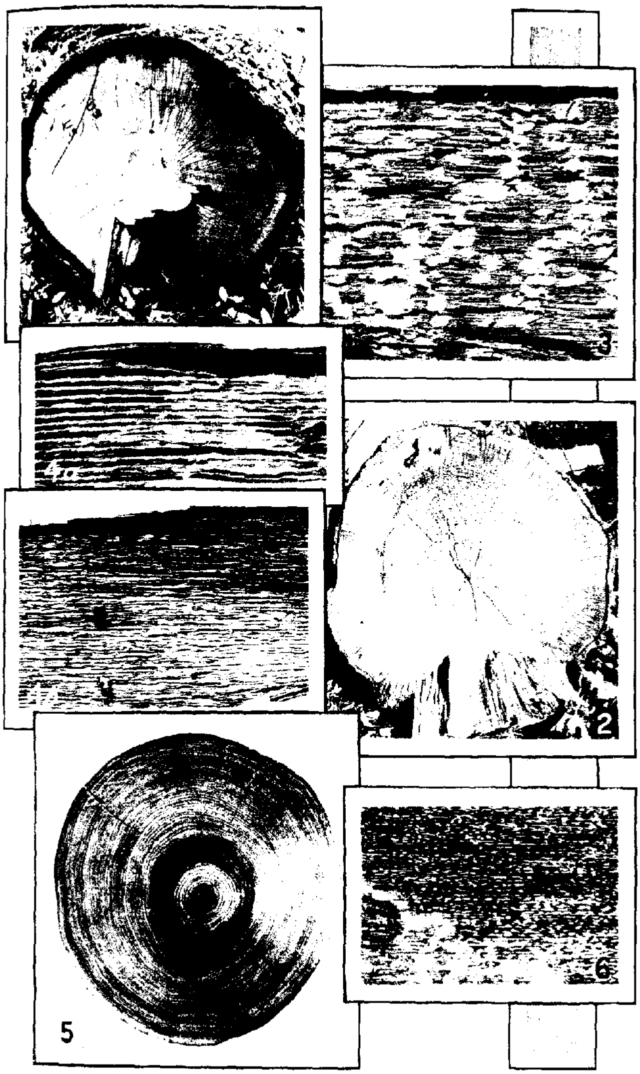
Fig. 6.—*Polyporus pilotae:* Radial-longitudinal view of the rot in a chestnut log from New York, showing the white pocketed stage.

VIII. Fig. 1.—*Polyporus pilotae:* Radial-longitudinal view of the rot in a chestnut log from New York. This rot enters at a dead branch and then moves down the heartwood of the branch into the trunk.

Fig. 2.—*Polyporus berkeleyi:* Radial-longitudinal view of the rot in white-oak timber from Arkansas, showing the string and ray form characteristic of its second stage.

Fig. 3.—*Polyporus berkeleyi:* A sporophore on a white-oak root from Arkansas.

Fig. 4.—*Polyporus frondosus:* A sporophore on roots of white oak from Arkansas.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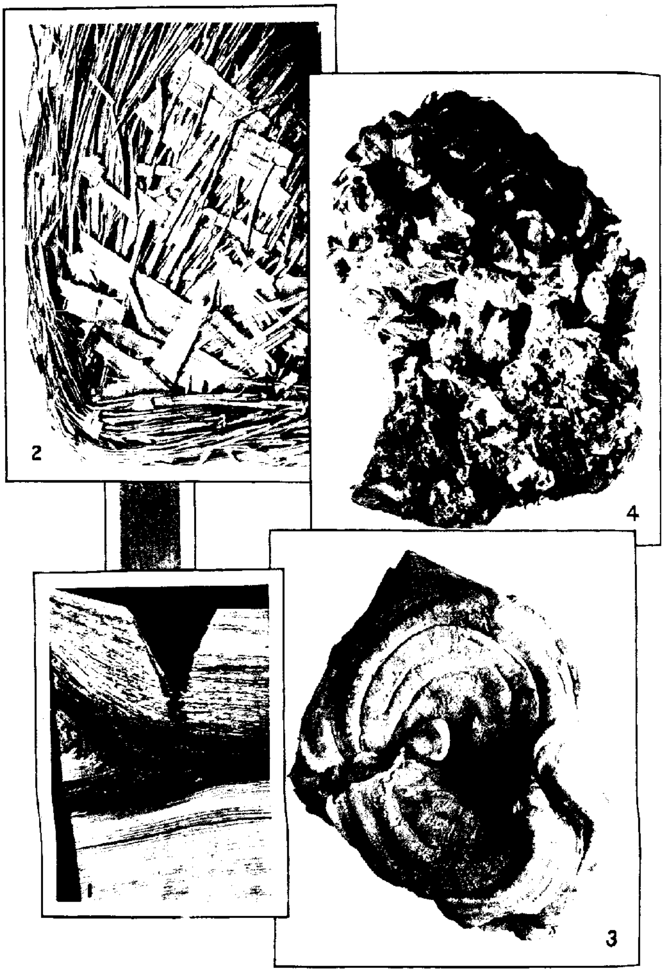

INDIVIDUAL VARIATION IN THE ALKALOIDAL CONTENT OF BELLADONNA PLANTS

By Arthur F. Sievers,

Chemical Biologist, Office of Drug-Plant and Poisonous-Plant Investigations, Bureau of Plant Industry

INTRODUCTION

It has long been recognized that a necessity exists for the improvement of the important medicinal plants. Within recent years agricultural science has been largely concerned with the improvement of crops by the application of the methods of plant breeding, but thus far practically no attempts have been made to extend these methods to drug plants with a view to improving their medicinal qualities. The chief aim in applying such methods should be to increase the active medicinal constituents rather than to improve the appearance of the plants. That the amount of a chemical constituent in a plant can be favorably modified by selection has been amply proved by work which has been done on the sugar beet, and there is reason to believe, therefore, that similar efforts with the economically important medicinal plants will be attended with success.

One of the first steps necessary to inaugurate such a plan is to determine the variation of the active constituents in individual plants and the extent to which such variation is influenced, if at all, by the various factors affecting the growth and cultivation of the plants. This article deals entirely with such a study. The results herein set forth furnish a basis for the application of the principle of selection as the next step in the solution of the problem.

Atropa belladonna was selected as a suitable plant with which to work, since it is probably the most important of the group of solanaceous plants which depend for their therapeutic action on mydriatic alkaloids. The supply of this plant in the wild state is largely exhausted and future supplies must necessarily depend on cultivation. The alkaloids which it contains can be definitely determined by chemical assay, which is a distinct advantage in a problem of this kind.

The writer wishes to emphasize the fact that the work thus far done constitutes but a preliminary step toward the application of the methods of selective breeding, which has already been begun. Considerable interest attaches to the results presented in this article because they represent the first extensive study of the variation of the quantity of alkaloids in this important economic plant.

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VARIATIONS IN THE ALKALOIDAL CONTENT OF LEAVES OF DIFFERENT BELLADONNA PLANTS

METHOD OF INVESTIGATION

The object of this investigation was to study the variation in the alkaloidal content of the leaves of individual belladonna plants and to establish, if possible, some correlation between the appearance of the plant and the variation of active constituents, should any variation exist. It was decided that the plants to be used for this purpose should be selected entirely at random, and they were therefore taken from all sections of the plat without reference to size or thriftiness. This afforded an opportunity to study the relationship of growth to alkaloidal content of the leaves. The field work was carried on at Arlington, Va., Bell, Md., and Madison, Wis. The Arlington plat was the largest, and the large number of plants at that place furnished the most complete data.

The general plan followed was to pick the leaves from each plant at different times during the growing season so as to be able to determine the proper time of the year in which the leaves should be picked in order to insure the greatest percentage of alkaloids. This should have the further advantage of showing whether individual plants which contain an abnormally high or low percentage of alkaloids in the leaves at one time of the year possess the same feature at other times.

Unfortunately this program could not be followed the first year, owing to pressure of other work. In some cases, especially early in the season, the plants were too small to furnish sufficient leaves for an assay without being entirely denuded. The smallest amount of dry material that could be used in the assay was 2 grams, and in order to insure a duplicate assay it would be necessary to have at least 25 grams of green leaves. Immediately after picking, the leaves were spread out evenly on a table in a dry, well-ventilated room until air-dry. They were then placed in small cloth bags until assayed.

The development of this investigation has been somewhat retarded through the loss of a number of the plants under observation. The loss was especially severe in the lower section of the plat, where the drainage is poor. The plants wilted suddenly and rapidly and the roots became entirely decayed. The loss was greatest after a prolonged wet spell, and after the trouble had once manifested itself the plants only occasionally recovered. Holmes[1] says that the cultivation of belladonna can rarely be continued beyond the third year, as the increased weight of the plants has a tendency to split the roots, thus permitting the water to enter and rot them. This may possibly be the trouble encountered here, but there is little evidence to show that the weight of the plant or mechanical injury is responsible, as both young and old plants suffered from the trouble.

[1] Holmes, E. M. The cultivation of medicinal plants in Lincolnshire. Pharm. Jour., s. 3, v. 12, Sept. 17, p. 237–239, 1881.

RESULTS OF THREE YEARS' OBSERVATION

During the summer of 1909 three rows of belladonna plants were started at the Arlington Experimental Farm directly from field sowing. The plants made a fair growth in the late summer and fall, but did not bear seed. The following spring they made a good growth and 24 plants were carefully staked out for this investigation. Since the plants made only a partial growth in the preceding year, they were considered as first-year plants and are so referred to throughout this article. The only picking from these plants in the first year was made in June, when most of the plants were in full bloom, although some were bearing berries of considerable size. Table I shows the general physical condition of the plants and gives the percentage of alkaloids in the leaves of each individual plant.

TABLE I.—*Description of individual first-year belladonna plants and percentage of alkaloids in the leaves of each at Arlington Experimental Farm in June, 1910.*

Plant No.	Stage of growth.	Description of plant.			Remarks.	Alkaloids.
		Height.	Spread.	Number of stems.		
		Inches.	*Feet.*			*Per cent.*
1	Not yet flowering....	12	1 by 1½	1	....	0.645
2	Few flowers..........	18	2 by 2½	5	....	.618
3	.....do..............	12	3½ by 2½	8	....	.528
4	Slightly past flowering.	24	1½ by 3	5	....	.495
5	Flowers and some berries.	18	1 by 3	4	....	.334
6	.....do..............	12	3 by 3¼	4	Squatty............	.459
7	.....do..............	24	2½ by 3½	4	Tall................	.667
8	Many flowers.........	21	1½ by 3	3	One branch tall and erect.	.657
9	Flowers and a few berries.	21	1½ by 4	2	....	.563
10	Many flowers.........	42	3½ by 4½	2	....	.536
11	Flowers and berries..	18	3 by 3¾	5	....	.587
12	.....do..............	15	2 by 3¾	3	....	.603
13	.....do..............	21	3½ by 4¼	8	....	.700
14	.....do..............	21	3 by 3	12	....	.656
15	.....do..............	24	3 by 4	8	....	.555
16	.....do..............	24	1½ by 3½	2	....	.544
17	.....do..............	15	2½ by 4	3	....	.485
18	Flowers and a few berries.	24	2 by 2¼	5	Very backward in development.	.462
19	Flowers..............	12	1½ by 1¾	3	....	.440
20	Not yet flowering....	15	1½ by 2	1	Poorly developed...	.473
21	.....do..............	18	1 by 1½	1	.....do.............	.587
22	Flowers and berries..	12	2 by 4	3	....	.623
23	Not yet flowering....	12	1¼ by 1½	1	Poorly developed...	.412
24	Flowers..............	18	1¾ by 1½	1	....	.503
	Average..............	......	......	......	....	.547

Since one picking showed such a wide range of variation among the 24 plants, 35 additional plants were staked out the following spring. Twenty-six of these were in the same plat as the first plants, while the remaining 9 were in a neighboring plat on practically the same kind of soil and were separated from the others by a space of only about 100 feet. These 9 plants are distinguished in Table II by the letter "w."

Table II represents the results of the second and third years. In 1911, five pickings were made, extending from May 12 to October 17. At each picking the height of each plant was measured, until the full stage of development had been reached. At the first picking, on May 12, nine of the plants were not sufficiently advanced to furnish samples of leaves. Some of the more advanced plants were beginning to have flowers. On May 22, when the second picking was made, the plants were all in the full flowering stage. The third picking was made on June 17, when the flowering was mostly over and the berries generally were well developed. The plants had made considerable growth since the previous picking, but by the latter part of June they had reached their maximum growth. At the time of the fourth picking, September 6, they had assumed their characteristic late-summer and fall appearance. The berries were ripe and the leaves were small and sparse. At this stage the picking of the leaves is a very tedious process. Later in the fall, after the berries are ripe, new leaves begin to appear on the plant. Many of them develop on the new sprouts which mature during the summer, and not a few appear as the result of suckers which sprout directly from the roots. It has frequently been observed that some plants develop so many of these suckers that they have the appearance of plants just before flowering. At this stage, October 17, the fifth and last picking was made.

TABLE II.—*Description of belladonna plants and percentage of alkaloids in the leaves of each at different stages of growth in 1911 and 1912.*

Season of 1911.

Plant No.	Description of plant.				Alkaloids (per cent).					
	Number of stems.	Height (inches).								
		May 12.	May 22.	June 17.	First picking (May 12).	Second picking (May 22).	Third picking (June 17).	Fourth picking (Sept. 6).	Fifth picking (Oct. 17).	Average for season.
1	1		4	12	....	....	....	0.823	0.687	0.755
2	5	6	15	24	0.852	0.698	0.583	.804	.619	.711
3	5	12	15	28	.384	.375	.277	.549	.451	.407
4	12	18	30	40	.461	.334	.304	.824	.665	.518
5	3	8	16	24	.493	.700	.478	.681	.546	.579
6	4	10	18	28	.484	....	.371	.630	.610	.524
7	5	9	20	42	.714	.622	.440	.765	.470	.602
8	4	8	16	30	.520	.618	.423	.891	.528	.596
9	2	6	12	29	....	.627	.460	.781	.452	.580
10	7	13	22	38	.382	.344	.450	.671	.670	.503
11	7	8	17	33	.699	.677	.567	.537	.618	.619
12	3	15	30	39	.649	.782	.693	.497	.584	.641
13	9	18	32	42	.614	.627	.626	.763	.563	.639
14	10	9	24	38	.480	.556	.474	.476	.455	.488
15	4	16	30	45	.452	....	.562	.546	.418	.494
16	5	14	22	36	.455	.754	.624	.622	.592	.609
17	7	12	24	30	.487	....	.534	.396	.474	.473
18	10	11	22	30	.477	.645	.481	.634	.519	.551
19	6	6	15	30	.356	.386	.356	.507	.532	.427
20	2	6	16	24	....	.489	.795	.509	.479	.568
21	3	6	12	22	....	.535	.633	.669	.684	.630
22	4	12	22	30	.423	.410	.428	.454	.557	.454
23	4	7	16	28	....	.348	.354	.487	.425	.403
24	4	5	11	24	....	.349	.392	....	....	.370
25	3	8	20	33	....	.277	.335	....	....	.306
26	4	11	22	35	.395	.378	.527	.797	.733	.567

Season of 1912.

Plant No.	Description of plant.				Alkaloids (per cent).					
	Number of stems.	Height (inches).								
		May 9.	May 21.	June 18.	First picking (May 10).	Second picking (May 21).	Third picking (June 18).	Fourth picking (Sept. 10).	Fifth picking (Oct. 17).	Average for season.
1	1	10	15	22	....	0.332	0.503	0.653	0.417	0.501
2	3	19	16	23	....	.558	.700	.407	.606	.568
3	5	12	16	19	....	.393	.448	.448	....	.429
4	13	30	34	36	0.522	.557	.469	.654	.591	.559
5	4	12	16	20	....	.438	....	.510	....	.474
6	9	21	22	30	.462	.415	....	.548	.465	.472
7	5	21	28	32	....	.424	.447	.689	.296	.464
8	2	12	17	20	....	....	.652	.726	....	.689
9	3	14	22	20	.560	.384	.402	.501	....	.429
10	13	33	40	43	....	.421	.438	.457	....	.420
11	4	14	19	21	....	.388	.609	.692	.223	.499
12	6	20	25	30	.767	.631	.685	.715	.308	.638
13	10	28	32	34	.495	.479	.65[illegible]	.272	.394	.518
14	15	30	33	36	.553	.421	.457	.359	.488	.420
15	9	34	36	44	.641	.531	.567	.462	.310	.550
16	8	17	22	32	.716	.631	.545	....	....	.631
17	14	32	34	37	.684	.591	.559	....	....	.611
18	9	27	32	31	.553	.386	.662	....	....	.534
19	18	27	30	37	.560	.423	.475	....	....	.486
20	7	20	20	25	....	.676	.681	....	....	.678
21	5	25	34	34	.732	.719	.781	....	....	.744
22	7	25	30	30	.703	.593	.462	....	....	.586
23	8	21	26	36	.496	.366	.341	....	....	.401
24	....	....	....	....	....	....	....	....	....	....
25	6	20	28	35	.521	.438	.508	....	....	.489
26	12	25	30	36	.869	.700	.609	....	....	.726

27	2	9	18	30	......	.287	.432	.554	.495	.442	8	28	29	35	.754	.693	.521	......	......	.656
28	3	12	20	30	.304	.392	.513	.740	.614	.513	9	27	31	35	.657	.535	.525	......	......	.572
29	2	8	21	30	......	.655	.914	.908	.547	.756	5	22	25	31	.737	.647	.729	......	......	.704
30	7	10	17	30	.387	.573	.512	.653	.527	.530	9	24	25	29	.655	.553	.507	......	......	.572
31	5	12	20	33	.381	.430	.458	.669	.384	.464	1	3	7	7	......	......	......	......	......	......
32	5	13	20	32	.409	.425	.546	.703	.549	.526	7	24	27	31	.533	.446	.646	......	......	.542
33	12	13	23	36	.481	.447	.549	.496	.458	.486	5	22	25	28	.602	.589	.576	......	......	.589
34	4	12	22	33	.335	......	.526	.532	.200	.414	4	19	23	26	......	.292	.520	......	......	.406
35	3	15	26	36	.323	.476	.534	.768	.524	.430	7	24	31	40	.608	.596	.732	.590	.549	.616
36	3	12	24	39	.320	.468	.482	.488	.473	.446	6	27	33	38	.469	.418	.598	.555	.378	.483
37	4	11	20	30	.323	.423	.550	.719	.558	.515	6	22	30	33	.598	.442	.475	.705	.523	.548
38	5	11	20	34	.532	.514	.552	.749	.630	.595	8	23	28	34	.454	.463	.520	.586	......	.506
39	9	15	30	37	.303	.262	.327	.614	.451	.391	6	25	30	36	.404	.365	.525	.600	......	.473
40	6	17	34	39	.405	.395	......	.797	.644	.560	15	26	34	35	.575	.556	.469	......	......	.533
41	2	16	28	36	.318	.390	.456	.562	.414	.428	7	29	32	36	.508	.512	.524	.470	.332	.469
42	3	15	30	36	.494	.526	.497	.615	.528	.533	4	24	28	34	.617	.664	.648	.789	......	.679
43	3	12	28	40	.515	.567	.534	.547	.331	.499	4	19	26	30	.506	.365	.698	.562	......	.533
44	2	20	31	36	.342	.497	.448	.626	.550	.489	3	25	27	26	.458	......	.467	......	......	.463
45	6	15	30	40	.467	.410	.428	.759	.379	.488	11	24	30	38	.601	.501	.382	.430	.384	.460
46	5	13	26	40	.337	.285	.308	.588	.431	.390	9	21	34	30	.418	.334	.480	.483	.314	.406
47	5	14	26	36	.389	.422	.400	.573	.482	.453	6	27	32	38	......	.479	.572	.449	.522	.505
48	4	14	24	36	.494	.493	.539	.748	......	.568	3	21	28	30	.426	.346	.590	.567	.332	.452
49	5	17	27	42	.583	.476	......	.668	.505	.558	7	21	25	26	.556	.476	.457	.578	.399	.481
50	8	10	19	30	.610	.583	.447	.619	.379	.527	3	13	19	24	......	.361	.328	.420	......	.353
1W	17	8	21	28	.638	.835	.587	.738	.612	.682	8	12	20	28	.737	.642	.777	......	......	.719
2W	7	12	28	36	.444	.769	.614	.311	.518	.531	7	24	30	32	.573	.544	.563	......	......	.560
5W	17	18	34	39	.464	......	.741	.638	.595	.584	18	28	39	42	.741	.602	.524	.806	.647	.664
6W	8	19	33	39	.596	.879	.925	.711	.722	.766	8	25	28	34	.847	.747	.882	.804	.558	.768
7W	13	16	32	36	.558	.831	.832	.727	.571	.704	15	36	37	35	.782	.666	.646	.694	.573	.672
8W	9	9	25	30	.578	.717	.538	.570	.481	.577	12	25	32	34	.634	.453	.280	.505	......	.468
9W	4	11	23	30	.487	.767	.553	.425	.337	.514	5	16	25	28	.557	.429	.638	......	......	.541
10W	6	14	26	26	.587	.763	.690	.473	.424	.587	8	20	25	28	.751	.478	.505	.639	.678	.610
11W	6	11	24	30	.425	.521	.373	.479	.420	.444	3	19	26	30	.773	.562	.430	.402	......	.544
Average	......	......	......	......	.472	.528	.517	.633	.519	.532	......	......	......	......	.601	.503	.553	.568	.447	.545

In 1912 the same line of observation was followed in connection with the same plants and the results are also included in Table II. Unfortunately, the disease described elsewhere killed fully one-half of the plants by the end of the season. Therefore, the results given in the table are not as complete as those of the previous year, especially with regard to the fourth and fifth pickings. The stages of growth at which the pickings were made correspond closely to those of the previous year, as the dates indicate.

At the drug-testing garden at Bell, Md., where the soil is quite different from that at Arlington Experimental Farm, 19 individual plants were under observation and three pickings of leaves were made. Owing to a delay, no picking was made at the time of the first picking at Arlington, although the plants at both places were at the same stage of development. Consequently, the picking on May 27, which is designated as the first at Bell, corresponds to the second picking of the Arlington plants. Table III shows the results.

TABLE III.—*Description of individual belladonna plants and percentage of alkaloids in the leaves of each at different stages of growth, at Bell, Md., in 1911.*

Plant No.	Description of plant.			Alkaloids (per cent).			
	Number of stems.	Height (inches).					
		May 27.	June 22.	First picking May 27.	Second picking June 22.	Third picking Oct. 17.	Average for season.
1	5	22	22	0.329	0.288	0.422	0.346
2	4	19	22	.474	.502	.395	.457
3	8	20	24	.485	.408	.641	.511
4	4	23	26	.639	.686	.570	.632
5	3	24	24	.659	.637	.415	.570
6	2	25	24	.577	.637	.559	.624
7	4	23	24	.654	.722	.482	.619
8	3	25	24	.467	.464	....	.466
9	3	24	26	.526	.595	.350	.477
10	6	23	26	.752	.600	.418	.590
11	4	15	18	.571	.485	.579	.545
12	5	26	28	.548	....	.424	.486
13	5	22	24	.695	.587	.750	.677
14	5	27	30	.407	.605	....	.506
15	3	16	18	.436	....	.448	.442
16	5	30	28	.466	.390	.511	.456
17	7	28	30	.823	.665	.527	.675
18	6	33	34	.754	.689	.502	.648
19	6	24	22	.782	.783	.556	.707

At the drug-testing garden at Madison, Wis., observations similar to those at Arlington have been made for two years, and the results are given in Table IV. The first nine plants were under observation in 1911 and 1912, while the last eight were sent to Madison from Arlington as young seedlings in the spring of 1912. No notes were taken of the individual plants with regard to height, spread, and number of stems, since they were all very much alike. Each plant acquired a height of about 2 feet and had an average of three or four stems each.

The stages of growth at which these pickings were made correspond closely to the first, second, and third pickings at Arlington, irrespective of the dates. Since Madison is farther north than Washington, the plants came up later in spring than in the vicinity of Washington and did not reach the full flowering stage until in July or early in August.

TABLE IV.—*Description of individual belladonna plants and percentage of alkaloids in the leaves of each at different stages of growth at Madison, Wis., in 1911 and 1912.*

Plant No.	Season of 1911.								Season of 1912.									Average alkaloids for two seasons.
	General appearance and size of plant.[1]				Alkaloids (per cent).				General appearance and size of plant.				Alkaloids (per cent).					
	Appearance.	Height.	Spread.	Stems.	June 20.	July 5.	July 31.	Average for season.	Appearance.	Height.	Spread.	Stems.	June 24.	July 13.	July 15.	Aug. 7.	Average for season.	
		In.	*In.*							*In.*	*In.*							*Per ct.*
1[2]	Excellent	18	18	2	0.566	0.548	0.767	0.627	Excellent									
2	Good	12	12	4	.496	.478	.528	.500	Good	30	36	8	0.351	0.519			0.435	0.468
3	do	16	18	2	.580	.501	.520	.533	do	30	24	4	.268	.501			.385	.459
4	Poor	8	12	3	.492	.427	.420	.446	do	30	30	6	.392	.417			.405	.426
5	Excellent	18	18	3	.493	.545	.508	.515	Excellent	42	48	13	.299	.445			.372	.444
6	do	18	18	3	.418	.466	.664	.516	do	39	48	11	.307	.316			.312	.414
7	Fair	12	18	2		.442	.419	.430	Fair	27	24	5	.507	.534			.521	.476
8	Poor	12	18	1	.558	.539	.485	.527	do	18	18	7	.500	.404			.452	.489
9[3]	do	8	16	2	.561	.820	.615	.665										
Average					.521	.529	.547	.529					.375	.448			.411	.454
10															0.323	0.397	.360	
11															.360	.496	.428	
12															.350	.412	.381	
13															.416	.408	.412	
14															.311	.497	.404	
15															.261	.252	.257	
16															.305	.378	.342	
17															.409	.508	.459	
Average															.342	.428	.380	

[1] These data were taken at the time the last picking was made. By the end of the growing season, October 15, the plants had greatly increased in spread and also somewhat in height. This was due largely to the new fall growth.
[2] In 1912 this plant did not appear above ground until August 1.
[3] This plant was dead in 1912.

RELATION OF THE ALKALOIDAL CONTENT OF THE LEAVES TO THE STAGE OF GROWTH OF THE PLANT

Opinions have been expressed from time to time as to the proper stage in the growth of the belladonna plant at which the leaves should be picked in order to insure the greatest percentage of alkaloids. Owing to the standard required by the Pharmacopœia, this is a question of no small economic importance. Gerrard[1] has found that the plant is not rich in alkaloids before flowering, but that the full development is reached at the period of flowering and is maintained in both the roots and leaves into the fruiting season.

The large number of assays of the leaves of individual plants here involved presents exceptional opportunity for the study of the above question. The proper season for the picking of belladonna leaves does not, however, depend entirely on the percentage of active constituents present. This will become very evident when the data at hand are thoroughly interpreted. Table V shows in condensed form the number of plants in which there was an increase or decrease in the percentage of alkaloids in the leaves at the various pickings.

TABLE V.—*Number of belladonna plants which showed an increase or decrease in percentage of alkaloids in the leaves at the second, third, fourth, and fifth pickings as compared with the preceding picking at Arlington Experimental Farm in 1911 and 1912.*

Stage of growth.	Season of 1911.			Season of 1912.		
	Total number of plants.	Number of plants which showed—		Total number of plants.	Number of plants which showed—	
		Increase.	Decrease.		Increase.	Decrease.
Second picking	70	38	32	59	16	43
Third picking	60	25	35	53	34	29
Fourth picking	54	40	14	32	20	12
Fifth picking	56	8	48	23	4	19

Table V shows that in 1911 the leaves of most of the plants were richer in alkaloids at the second picking than at the first, which is in accord with the observations of Gerrard, already noted. In 1912, however, the opposite is true. It will be seen further that in the fourth picking of both years the greatest number of plants showed an increase in the alkaloidal content of their leaves. Referring to Table II, it is seen that in the fourth picking in 1911 the average quantity of alkaloids for the leaves of all the Arlington plants was 0.633 per cent, or more than one-tenth of 1 per cent than at the flowering stage. In 1912, at

[1] Gerrard, A. W. On the alkaloidal value of belladonna plants at different periods of growth. Yearbook of Pharmacy, 1881–1882, p. 400–404, 1882.

this same stage, the average was 0.568 per cent of alkaloids, which is 0.065 per cent higher than the average at the flowering stage, although lower in this case than at the early stage. There appears to be but a slight difference so far as the alkaloidal content is concerned between the flowering stage and the early fruiting stage. At the last, or fifth, picking, the plants had acquired much new growth and, judging from the average results, the percentage of alkaloids present in the leaves at that stage was not much different from the second and third stages.

Although the experiments show that the leaves are richest in alkaloids at the late fruiting stage of the plant, collection at that time for commercial purposes is practically out of the question because the leaves are of very small size. After the flowering period is over and the berries are ripening many of the large leaves fall off and numerous small, bractlike leaves develop. These, while apparently rich in alkaloids, could not be picked to advantage in large quantities.

RELATION OF SIZE AND APPEARANCE OF PLANTS TO ALKALOIDAL CONTENT OF LEAVES

When this investigation was first undertaken it was hoped that some relationship might be found to exist between the physical appearance of the plants and the alkaloidal content of their leaves, for should such relationship exist the process of distinguishing between the good and the poor plants with regard to their active constitutents would become a much simpler matter than by use of the assay method, since the latter is necessarily tedious.

The variations in the physical appearance of belladonna plants depend largely on the height and the number of stalks or stems. When height is referred to here, the actual length of the stems from the ground to the tips is meant rather than the vertical distance of the topmost branches from the ground. This distinction is necessary because many of the branches droop or grow at an angle. The spread of the plant, that is, the distance around, is largely dependent upon the angles at which the branches are growing and on the number of stems of the plant. The height of the plant and the number of stems, therefore, are the two distinguishing features as regards size. These indicate also the relative health and vigor of the plant. An attempt was made to differentiate between various types of leaves, with reference to size and color and between different types as regards blooming and fruiting tendencies. It was found difficult, however, to find individuals which conformed definitely to any particular type. Where certain characteristics existed they were not as a rule general over the entire plant, but were usually found on only one side or on only certain stems. Thus, in some cases, one or two stems of a plant bore what appeared to be leaves of a larger size than usual and of a different shade of green,

while the remainder of the plant was in every respect like most of the other plants. The same would be true of the number of flowers and berries. In such cases it could not be assumed that the plant represented any special type. It was also noticed that some of these distinctive features were subject to gradual changes, so that their distinctiveness was soon lost.

While the number of plants that have been under observation was probably not sufficiently large to show conclusively that there is no definite correlation between physical appearance and active medicinal properties in the leaves, yet from the data at hand such a condition is at least indicated. Henderson,[1] in commenting on the great variation in the alkaloidal content of different lots of belladonna roots, points out that appearance is no criterion of the quality, the best appearing roots being often the poorest in medicinal value.

To show by actual examples that there is apparently no relation between the appearance of the plant and its alkaloidal content it is necessary only to refer to the tables. For example, in Table I plant No. 10 has a height of 42 inches and a spread of 3½ by 4½ feet; in fact, it is the largest plant in the list, yet its leaves contain only 0.536 per cent of alkaloids, which is a trifle less than the average of all the plants. On the other hand, plant No. 8, which is only half as high and much smaller in spread, shows 0.657 per cent of alkaloids in its leaves. Again, in Table II (season of 1911) plant No. 15 is the largest in the plat in point of height, yet its leaves assayed only 0.494 per cent, or less than the average quantity of alkaloids. A similar statement may be made in regard to large plants Nos. 4, 43, 45, and 46, while, on the other hand, the leaves of the comparatively small plants, Nos. 21, 29, and 1w, contained 0.630, 0.756, and 0.682 per cent of alkaloids, respectively. The data show that in the following year these same plants failed again to compare favorably with others as regards size, yet the percentages of active constituent in their leaves stand out prominently above the average. However, plants can be pointed out in the same table which are larger and apparently more vigorous than the average and which also contain above the average percentage of alkaloids in their leaves. The lack of correlation is therefore very evident.

VARIATION AMONG PLANTS

Among the facts brought out by this investigation probably the most important is the great variation in the percentage of alkaloids found in the leaves of individual plants at each of the three testing gardens. That some variation should exist was to be expected, since variations are often noted in the chemical constituents of different plants of many

[1] Henderson, H. J. **Percentage of alkaloid in belladonna root.** Pharm. Jour., v. 75, no. 3485 (s. 4, v. 21, no. 1832), p. 191, 1905.

other species. The knowledge of the existence of such individual variations should have an important bearing on the question of the improvement of drug plants by selection and cultivation.

To show the great variation found among the comparatively limited number of plants under observation Table VI is here presented.

TABLE VI.—*Range of variation in percentage of alkaloids in the leaves of belladonna plants at each stage of growth, at Arlington, Madison, and Bell stations, in different years.*

Stage of growth.	Alkaloidal content of the leaves (per cent).											
	Arlington, Va.						Madison, Wis.				Bell, Md.	
	1910.		1911.		1912.		1911.		1912.		1911.	
	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.
First picking	......	......	0.852	0.303	0.869	0.404	0.580	0.418	0.500	0.268	0.823	0.329
Second picking	0.700	0.334	.879	.262	.747	.292	.820	.427	.519	.316	.783	.288
Third picking	......	......	.925	.277	.882	.328	.767	.419	......	......	.750	.395
Fourth picking	......	......	.891	.311	.806	.359	......	......	......	......	......	......
Fifth picking	......	......	.733	.200	.678	.296	......	......	......	......	......	......
Season average	......	......	.766	.306	.768	.353	.665	.430	.452	.312	.707	.346
Average	......	......	.841	.277	.792	.339	.708	.423	.490	.298	.766	.339

From this tabulation it appears that the active principle is more than three times as great in the leaves of some plants as in those of others at the same period of growth, although the plants are in the same plat and therefore grow practically in the same soil and under the same climatic conditions. Under such circumstances the existing variation can hardly be attributed to anything but the inherent characteristic of the individual plant. Much has been written concerning the influence of soil and climate on the formation of alkaloids in the plants. Gerrard[1] has found that a chalky soil favors the formation of atropin. Chevalier[2] concludes from his experiments with fertilizers that the alkaloidal content of certain Solanaceæ can be increased by means of nitrates and farmyard manures. Ransom and Henderson,[3] however, who are working along the line of Chevalier's experiment, have not found thus far that artificial manures materially affect the percentage of alkaloids in the dried leaf, but note in several cases a large increase in the yield of the

[1] Gerrard, A. W. Op. cit.

[2] Chevalier, J. Influence de la culture sur la teneur en alcaloïdes de quelques Solanèes. Compt. Rend. Acad. Sci. (Paris), t. 150, p. 344–346. 1910.

[3] Ransom, Francis, and Henderson, H. J. Belladonna: the effects of cultivation and fertilizers on the growth of the plant and its alkaloidal content. Chemist and Druggist, v. 81, no. 1703, p. 53–55. 1912.

green plant per acre. Carr[1] claims to have found a certain relationship between the amount of sunshine during the growth of the plant and the percentage of alkaloids found in the stems and leaves, claiming that plenty of sunshine and limited rainfall have a tendency to stimulate the production of alkaloids.

Although soil and climate may have considerable influence on the alkaloidal content of plants, yet to establish this as a fact beyond all doubt is a difficult matter because of the individual variation involved. Until experiments have been conducted upon a large number of plants which show a minimum variation in their alkaloidal content, nothing definite can be said upon this point. In working with a limited number of plants collectively, an abnormally low or high percentage of alkaloids in the leaves of a few might so affect the yield as to make the average entirely misleading. Likewise, this individual variation becomes an important matter in the sampling of large quantities of leaves and roots. In order to secure a reliable sample, it should be of considerable size and selected only after the leaves or roots have been thoroughly mixed.

INDIVIDUAL VARIATION THROUGH SEVERAL SEASONS

Having definitely established the fact that great variations exist in the alkaloidal content of the leaves of individual plants, the question remains to be answered whether such variations exist only during one growing season or whether they manifest themselves in the same proportion in following seasons. If plants which are rich in alkaloids one season are correspondingly poor the following season, then it is logical to assume that the production of alkaloids in the plant is dependent on factors which change from year to year. If it were definitely known what rôle the alkaloids play in the metabolism of the plant, it might be easier to determine what factors influence their development. As has been shown, the physical appearance, or, in other words, the vitality and growing power of the plant, appears to bear no definite relation to the development of alkaloids. Furthermore, if soil and climate are the potent factors, then their influence ought to be felt by all plants alike when all are grown on similar soil and in the same locality. Such, however, has been found not to be the case, and reference to the tables shows that there were plants rich and poor in alkaloids in every year during which the observations extended. On the other hand, if it should be found that a plant with leaves containing an unusually high or low percentage of alkaloids in one season shows the same characteristics in following years, it would be safe to assume that there is a definite tendency in that plant to produce a small or a large quantity of alkaloids in the

[1] Carr, F. H. The effect of cultivation upon the alkaloidal content of Atropa belladonna. Chemist and Druggist, v. 81, no. 1703, p. 42–44, 1912.

course of a season's growth, just as in other plants there are well-defined tendencies toward certain physical characteristics.

This investigation, however, has hardly progressed far enough to yield any definite conclusions. In Table VII a comparison is made between

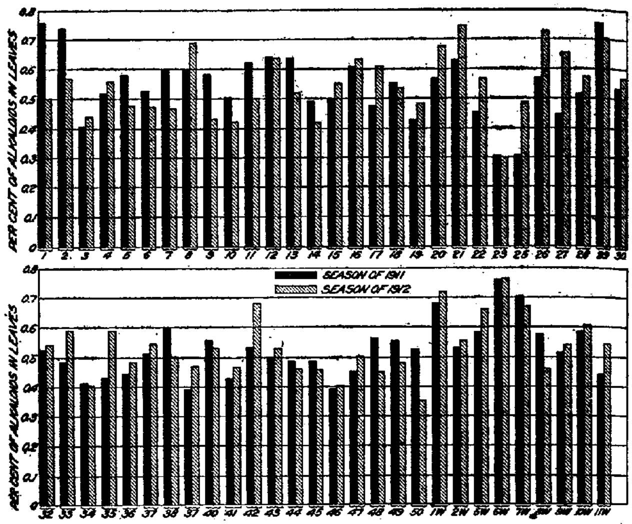

Fig. 1.—Diagram showing the percentage of alkaloids in thel eaves of individual belladonna plants at the Arlington Experimental Farm, Va., during the seasons of 1911 and 1912.

the years 1911 and 1912 of the 59 plants grown at Arlington, showing the variation of alkaloidal content above and below the average for each of the years mentioned. Figure 1 shows graphically the seasonal comparison.

TABLE VII.—*Percentage of alkaloids above and below the average*[1] *in the leaves of individual belladonna plants at Arlington, Va., in 1911 and 1912.*

[The figures given are based on the season averages of all the pickings. In each of the 40 plants designated by a star (*) the percentage of alkaloids above or below the average of the entire lot in 1911 varies by not more than one-tenth of 1 per cent from that in 1912.]

Plant No.	Alkaloids above (+) or below (−) the average (per cent).		Plant No.	Alkaloids above (+) or below (−) the average (per cent).	
	1911.	1912.		1911.	1912.
1	+0.223	−0.044	31	−0.068	....
2	+ .179	+ .023	32*	− .006	−0.003
3*	− .125	− .116	33*	− .046	+ .044
4*	− .014	+ .014	34*	− .118	− .139
5	+ .047	− .071	35	− .102	+ .071
6*	− .008	− .073	36*	− .086	− .062
7	+ .070	− .081	37*	− .017	+ .003
8*	+ .064	+ .144	38*	+ .063	+ .061
9	+ .048	− .116	39*	− .141	− .072
10*	− .029	− .125	40*	+ .028	− .012
11	+ .087	− .055	41*	− .104	− .076
12*	+ .109	+ .093	42	+ .001	+ .134
13	+ .107	− .023	43*	− .033	− .012
14*	− .044	− .125	44*	− .043	− .082
15*	− .038	+ .065	45*	− .044	− .085
16*	+ .077	+ .086	46*	− .142	− .139
17	− .059	+ .066	47*	− .079	− .040
18*	+ .019	− .011	48	+ .036	− .093
19*	− .005	− .059	49*	+ .024	− .064
20*	+ .036	+ .133	50	− .005	− .192
21*	+ .098	+ .199	1w*	+ .150	+ .174
22	− .078	+ .041	2w*	− .001	+ .015
23*	− .129	− .144	5w*	+ .052	+ .081
24	− .162	....	6w*	+ .234	+ .243
25	− .226	− .056	7w*	+ .172	+ .127
26	+ .035	+ .181	8w	+ .045	− .077
27	− .090	+ .111	9w*	− .018	− .004
28*	− .019	+ .027	10w*	+ .055	+ .065
29*	+ .224	+ .159	11w*	− .088	− .001
30*	− .002	+ .027			

[1] Average for 1911, 0.532 per cent; for 1912, 0.545 per cent.

In the plants in Table VII there are a number which are conspicuous because of the high or low percentage of alkaloids in their leaves. Plants Nos. 3, 23, 34, and 46 are without doubt greatly inferior to the others from a medicinal point of view. On the other hand, Nos. 21, 29, 1w, 6w, and 7w are greatly superior to any others in the list. Furthermore, these plants manifested the same characteristics not only on the average but at each picking. The recapitulation given in Table VIII shows this very clearly.

TABLE VIII.—*Alkaloidal content of the leaves of belladonna plants, rich and poor in alkaloids, at various stages of growth, in 1911 and 1912.*

Stage of growth (picking).	Plants with leaves of low alkaloidal content (per cent).							
	No. 3.		No. 23.		No. 34.		No. 46.	
	1911.	1912.	1911.	1912.	1911.	1912.	1911.	1912.
First	0.384	....	....	0.496	0.335	....	0.337	0.418
Second	.375	0.393	0.348	.366	....	0.292	.285	.334
Third	.277	.448	.354	.341	.526	.520	.308	.480
Fourth	.549	.448	.487	....	.532	....	.588	.483
Fifth	.451	....	.425	....	.200	....	.431	.314
Average	.407	.429	.403	.401	.414	.406	.390	.406

Stage of growth (picking).	Plants with leaves of high alkaloidal content (per cent).									
	No. 21.		No. 29.		No. 1w.		No. 6w.		No. 7w.	
	1911.	1912.	1911.	1912.	1911.	1912.	1911.	1912.	1911.	1912.
First	....	0.732	....	0.737	0.638	0.737	0.596	0.847	0.558	0.782
Second	0.535	.719	0.655	.647	.835	.642	.879	.747	.831	.666
Third	.633	.781	.914	.729	.587	.777	.925	.882	.832	.646
Fourth	.669	....	.908	....	.738	....	.711	.804	.727	.694
Fifth	.684	....	.547	....	.612	....	.722	.558	.571	.573
Average	.630	.744	.756	.704	.682	.719	.766	.768	.704	.672

SUMMARY

From the point of view of the percentage of alkaloids present in the leaves and the quantity of material available, the leaves can be picked to best advantage from the time of flowering until the early berries begin to ripen. Although the leaves are richer in alkaloids later in the season, they are then too small and sparse for harvesting.

Thus far nothing has been found to indicate that any correlation exists between the physical appearance of the plant and the alkaloidal content of its leaves. Luxuriant growth is by no means a criterion of the medicinal value of the plant.

The variation of the percentage of alkaloids in the leaves of the different plants is exceedingly large. This makes it a difficult matter to determine to what extent soil and climate influence the development of alkaloids. Where such wide variations exist among individual plants, the testing of a general sample from all plants collectively is not always a safe means of judgment.

A considerable number of plants with leaves rich in alkaloids in one season are found to have equally rich leaves in the following season. Furthermore, they frequently manifest the same characteristics at the various stages of growth during the season in comparison with other plants. The same facts are true with regard to plants which bear leaves with a low percentage of alkaloids.

THE PUBESCENT-FRUITED SPECIES OF PRUNUS OF THE SOUTHWESTERN STATES

By SILAS C. MASON,
Arboriculturist, Crop Physiology and Breeding Investigations, Bureau of Plant Industry

INTRODUCTION

The species of the genus Prunus described in this article occupy a unique position in the flora of the western United States from the fact that their relationship with the wild plums of the country is remote and they are more closely allied to some of the Asiatic species of this genus.

Their economic importance arises chiefly from their close adaptation to the climatic and soil conditions of the Southwest, where fluctuations of heat and cold, severe drought, and considerable alkalinity of the soil must be endured by most tree crops.

Adaptable stocks for the cultivated forms of Prunus capable of meeting such conditions are eagerly sought. Species with such characters which are capable of being hybridized with the old-established cultivated forms of the genus offer attractive possibilities to the plant breeder. This is especially true of the one edible-fruited form, *Prunus texana*, which affords in aroma and flavor of fruit most attractive characters for combination with other stone fruits of larger size and more staple commercial character.

Instead of forming a homogeneous group, as has usually been believed, these species fall into small groups of quite diverse character and affinities. To the plant breeder and student of their economic possibilities these relationships are of such importance that the following detailed study of them is deemed essential to an intelligent use of them in plant-breeding work.

In parts of the country beyond the Rocky Mountains a few ranchmen, occasionally a solitary mining prospector, and a few local botanists know of curious bushy plants growing in desert wastes having plumlike bark and twigs, oddly shaped leaves, and small downy fruits with thin dry flesh which have won for them the local names "wild almond" in the Great Basin region, "wild peach" or "desert almond" for another form in the Mohave Desert, and "wild apricot" or "wild almond" for a third form in the foothills bordering the Salton Basin in southern California.

A fourth form has been known for many years to the pioneers of eastern Texas, who have enjoyed eating the "wild peach" of their sandy

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country, the only really edible fruit of the group. However, this fruit is still strangely ignored by horticulturists and botanists alike.

A fifth form, growing in the limestone plains of central Texas, has a dry and inedible fruit which has not sufficiently attracted the attention of the cattlemen and goat herders in this sparsely settled region to earn a local name.

A sixth form, growing in the high altitudes of both northern and southern Mexico, though the first of all to receive botanical notice (1823) is still very rare in herbaria and has been seen in its native habitat by but few botanical explorers. It was first collected by Humboldt in his famous journey through the Mexican plateau region. A seventh species, Havard's wild almond, still very imperfectly known, has recently been described from the region inclosed by the Big Bend of the Rio Grande in western Texas.

We have, then, native to the region of North America, lying west of the Mississippi drainage area, six or seven members of the plum family differing in a very marked way from the familiar types of American wild plums.

They are united by the common character of a woolly or pubescent fruit, and all are deep-rooted, with remarkable drought resistance. This fruit character, so at variance[1] with the true plums of America or of the Old World, would at first seem to ally these species with the almond or apricot sections of the genus, as their common names suggest. A close examination of their botanical characters shows, however, that they fail to agree with those groups and must be regarded as occupying intermediate ground between the true plums on the one hand and the almonds or apricots on the other. Aside from the common character of pubescent fruit and their deep-rooting habit, these species differ widely from one another, which is to be expected from the wide geographic range which they occupy and the resulting differences in climate and soil.

HABITAT AND ENVIRONMENT

Ranging farthest north is the commonly named "wild almond" (*Prunus andersonii*), which is found around the shores of Pyramid Lake, Nev., in the Honey Lake region of California, and along the basin slopes of the Sierras, having an altitude range of from 4,000 to 8,000 feet in the Upper Sonoran and Transition life zones. (See map, fig. 1.) This is consequently subject to severe cold in winter, as much as 20° F. below zero in some instances, and to extreme drought and severe heat in the summer. It is usually found in gravelly or sandy soils.

Its near relative, the "wild apricot" (*Prunus eriogyna*), found along the desert slope of the San Bernardino and Santa Rosa Mountains and

[1] *Prunus oregana* Greene, of Oregon and northern California, has fruit with a fine, soft pubescence, but it is a true plum, near to *P. subcordata*.

southward into Lower California, is an inhabitant of much lower altitudes, at least in California. There it occurs at from 500 to 3,000 feet in the upper margin of the Lower Sonoran, but chiefly in the Upper Sonoran zone, extending a little below the zone of light winter snow, though subject to intense heat and prolonged drought in summer. (See map, fig. 1.)

Most similar to this species in habitat and requirements, though remote in relationship, is the "desert almond"[1] (*Prunus fasciculata*). This fruit

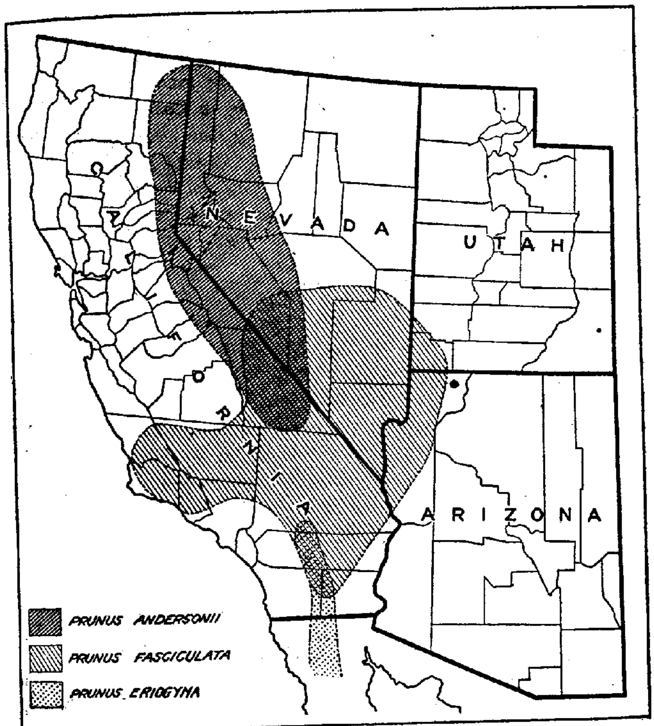

FIG. 1.—Map of the southwestern part of the United States, showing the range of *Prunus andersonii*, *Prunus fasciculata*, and *Prunus eriogyna*, n. sp.

occurs in widely scattered localities over a range which includes southern Nevada and California, together with the adjacent portions of Utah and Arizona. It overlaps portions of the areas of both *Prunus andersonii* and *Prunus eriogyna*, but, like the latter, is found in the upper margin of the Lower Sonoran and in the Upper Sonoran zones. (See map, fig. 1.) It

[1] Called "desert range almond" by Dr. C. H. Merriam in notes on the distribution of trees and shrubs in the deserts . . . U. S. Dept. Agr., Bur. Biol. Survey, North American Fauna, no. 7, p. 301, 1893.

is nowhere subject to the severe cold endured by the Nevada "wild almond" in its most northern habitat. It usually grows in gravelly formations or along washes or sandy slopes where deep root penetration is possible.

This "desert almond" is remote geographically from the two species of the group to which it is most nearly allied, the Texas wild almond, *Prunus minutiflora*, and its Mexican cousin, *Prunus microphylla*, which may consistently be called the "Mexican wild almond."

The Texas species has a range not yet well worked out, but it is apparently confined to the Cretaceous limestone region of the southwestern portion of the State, extending across the Rio Grande into the State of Chihuahua, Mexico, and probably occurring in Coahuila. Its known localities are entirely in the upper portion of the Lower Sonoran zone. (Fig. 2.) It is found over an area ranging in altitude from 750 feet near San Antonio to 3,000 feet near the mouth of the Pecos River, with an average rainfall of about 20 inches, but subject to periods of prolonged drought. There is an absolute temperature range for the years recorded of from zero to 110° F., with the liability to sudden drops from winter northers, peculiar to this region.

Of the conditions under which the Mexican species grows we have but indefinite knowledge, but it occurs at high altitudes—6,000 to 8,000 feet, the Upper Sonoran zone of this southern latitude, probably a mild temperate climate with light winter rains and heavy summer showers. In common with the other species it grows in a region where the setting of the fruit is frequently prevented by late spring frosts.

The little-known Havard's wild almond, *Prunus havardii*, apparently a near relative of these two species last mentioned, has been found so far only in western Texas.

The Texas "wild peach," *Prunus texana*, occurs in scattered localities over a region of eastern Texas from near sea level to nearly 2,000 feet in elevation, lying wholly in the Lower Sonoran or Lower Austral zones. This includes a portion of the western extremities of the corn and cotton belts, where an apparently sufficient annual rainfall is so unevenly distributed that long periods of drought make agriculture somewhat precarious and render irrigation a needful adjunct. It is adjacent to the area of *Prunus minutiflora*, but the division with its sharp demarcation is not one of climate, but of soils. *Prunus minutiflora* follows the Cretaceous limestone of the plateau region, while *Prunus texana* occurs on the mellow granitic sandy soil of the "Burnet Country" or the sandy loam of the Coastal Plain and is wholly wanting on limestone soils. (See map, fig. 2.)

BOTANICAL CHARACTERS OF THE GROUP

The botanical characters of the seven species under consideration, even the obvious character of the leaves and fruit, are so distinct from those generally recognized as belonging to wild or cultivated plums that it is not surprising that the Mohave Desert form was first assigned by Dr. Torrey to a new genus, Emplectocladus, from the Greek words referring to its interlocking branches. This was later placed in the genus Prunus by Gray, but as a separate section. Schneider, while including all these

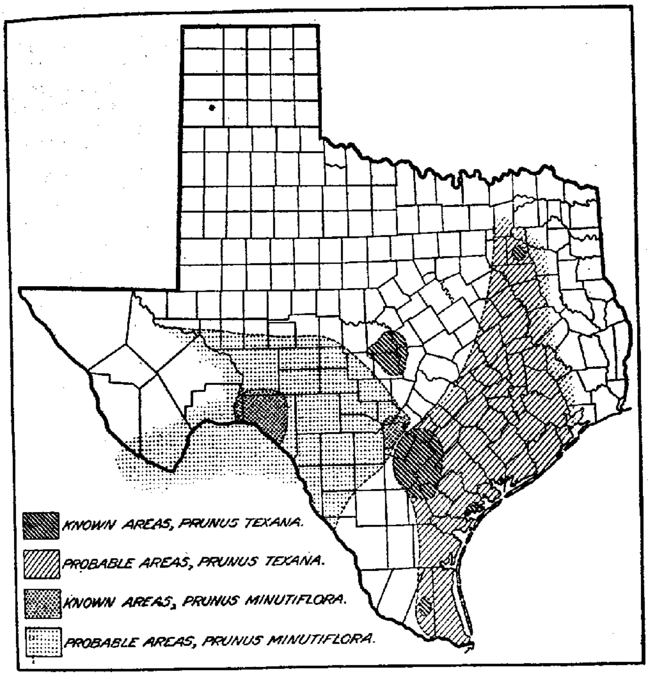

FIG. 2.—Map of Texas, showing the known areas and probable range of *Prunus minutiflora* and *Prunus texana*.

species under Prunus,[1] groups them in the section Emplectocladus along with Torrey's original species, *Prunus* (*Emplectocladus*) *fasciculata*, and the Old World *P. pedunculata*. Several authors have assigned some or all of the species to Amygdalus.

The study of the entire group from abundant material and the field examination of all but *Prunus microphylla* and *P. havardii* convince the writer that they are separable into three distinct sections.

[1] Schneider, C. K. Illustriertes Handbuch der Laubholzkunde. Bd. 1, Lfg. 4, Jena, 1905, p. 589–590.

The so-called wild almond (*Prunus andersonii*), chiefly found in Nevada, though also occurring along the eastern slope of the Sierras in California, is upon careful comparison found to be very closely related to the wild apricot (*Prunus eriogyna*) of the Colorado Desert in southern California. These two species are clearly separated from the peach and almond by the characters of the leaves both in vernation and when mature, by floral characters, and by the seeds.

The entire group (the genus Amygdalus of some authors) of the genus Prunus which includes the almonds and peaches has leaves folded lengthwise in the bud (conduplicate), the flowers sessile or subsessile, the stones rugose and pitted.

The Nevada wild almond, notwithstanding the fact that it has been described as being "a true almond in its affinities,"[1] and the desert apricot agree with the section Armeniaca, the apricots, in three important points: First, the leaves in the bud are rolled from the margin toward the middle, or convolute; second, the flowers are stalked, some on pedicels three-fourths of an inch long; and, third, the stones are smooth or but faintly pitted and decidedly wing-margined.

These characters are found also in some of the true plums, but a distinct separation from the plums is met in the rose-colored flowers and in the only slightly fleshy, pubescent fruits.

The presence of stomates in the upper surfaces of the leaves is a character distinguishing these two species from both the Amygdalus and Armeniaca sections.

Their characters as a whole, however, seem to unite them most closely with the apricots, and apparently there is nothing among the European and Asiatic forms of Prunus to which they are as closely related. Consequently the two species are here placed in a new section, Penarmeniaca (near-apricots).

The California desert almond (*Prunus fasciculata*), the Texas wild almond (*P. minutiflora*), and the Mexican wild almond (*P. microphylla*), agree in three important characters which separate them clearly from the three other species of this group. All three are diœcious by the abortion of either stamens or pistils; the number of the stamens is usually reduced to 10 or 15 and a portion of them inserted on the walls of the calyx cup. They further agree in having the inner face of the cup finely hairy instead of having a nectariferous surface as in apricots, peaches, and almonds. Havard's wild almond probably belongs in this same group.

Prunus fasciculata has leaves with stomates in the upper surface, in which it resembles *P. andersonii* and *P. eriogyna*, while the other three species have no stomates in the upper surface. However, on the strength of the characters possessed in common, especially of the remarkable one of the diœcious character of the flowers, *Prunus fasciculata* is placed with

[1] Greene, E. L. Flora Franciscana. [Pt. 1], San Francisco, [1891] p. 49.

the Texas and Mexican wild almonds in the subgenus Emplectocladus of Prunus. This has been done with a full realization that most definitions of this genus describe the flowers as perfect, though Sargent [1] and Schneider extend the definition to include polygamo-diœcious flowers. No reference to diœcious or polygamo-diœcious characters in any Asiatic forms of Prunus has been found.

While a more complete knowledge of the Asiatic forms[2] may disclose closer affinities for these three species, they are retained provisionally as the sole member of the subgenus Emplectocladus. With our present knowledge of these forms the seven species of Prunus studied in this paper should be grouped as follows:

SCHEME OF CLASSIFICATION

PRUNUS

SUBGENUS EMPLECTOCLADUS

Low divaricate or erect shrubs with more or less spinescent branches. Bark on new growth gray or brownish, glabrous or more or less pubescent. Leaves conduplicate in vernation; borne singly on vigorous young growth or apparently fascicled on budlike suppressed branchlet, with or without stomates in upper epidermis.

Flowers solitary or gemminate, sometimes crowded on short fruiting spurs, subsessile, precocious or coetaneous with the leaves, diœcious by the abortion of stamens or pistils; calyx cup obconic or campanulate, glabrous or faintly puberulous on the outer surface, minutely hairy within; stamens usually 10 to 15 on short filaments, in three more or less well-defined circles, inserted on the margin of the cup and on the walls below; ovary and base of style pubescent.

Fruit seldom more than 1 cm. long, pubescent, subglobose or irregularly ovate, with thin, dry flesh splitting tardily, and smooth or obscurely ridged stone.

Four species: *Prunus fasciculata* Gray, *Prunus minutiflora* Engelm., *Prunus microphylla* Hems., and *Prunus havardii* (Wight), n. comb.

SUBGENUS EUPRUNUS

SECTION PILOPRUNUS, N. SECT.

Low, much branched, often procumbent, scarcely spinescent shrubs, with gray or brown, pubescent young wood.

Leaves conduplicate, without stomates in upper epidermis, tomentose, glandular serrate.

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[1] Sargent, C. S. Silva of North America. Boston, 1892, v. 4, p. 7.

[2] *Prunus pedunculata* (Pall.) Maxim. and *P. pilosa* (Turcz.) Maxim. of Mongolia are said by Koehne (Pl. Wilsonianæ, pt. 2, p. 273) to have the calyx cup dry within and minutely hairy at the insertion of the stamens. Schneider figures (Laubhk., v. 1, p. 598, fig. 335 a) the whole interior of the calyx cup of *P. pedunculata* as finely hairy. Little is known as to the flower characters of *Prunus boissierii* Carr. from Asia Minor referred to *P. pedunculata* by Schneider, but which differs in having sessile flowers. These plants are referred to the section Emplectocladus by Schneider, but his figures of *P. pedunculata* show a perfect flower and no hint is given in descriptions of the other forms of their flowers being diœcious. These species, as well as the little-known *P. mongolica* and *P. dehiscens* Koch., grouped along with them by Koehne (Pl. Wilsonianæ, pt. 2, p. 274), and *P. petunnikowi* Litw. doubtfully referred to this group by Schneider (Laubhk., v. 2, p. 974), all need to be studied carefully so as to permit of a careful comparison with the American forms here referred to the section Emplectocladus.

Flowers white, appearing with the leaves, fascicled on short pubescent peduncles, perfect, highly fragrant; calyx cup campanulate, pubescent without, nectariferous within, with glandular serrate lobes; ovary finely pubescent.

Fruit 1.5 cm. to 2.5 cm. long, pubescent, the juicy, fragrant, highly flavored flesh clinging to the stone by a persistent velvety pile; stone rounded, smooth or scarcely furrowed.

One species: *Prunus texana* Dietr.

SECTION PENARMENIACA, N. SECT.

Dense shrubs with angled and thorny branches or of more smooth and erect arborescent growth reaching 3 meters in height; young twigs glabrous, reddish or yellow brown.

Leaves convolute in vernation, glabrous, more or less glandular serrate, with stomates in the upper epidermis.

Flowers rose colored, pale pink, or rarely white, solitary or in fascicles of two or three, on stalks from 5 to 15 mm. in length; stamens 20 or 30, inserted near the rim of the calyx cup; calyx cup campanulate, with nectariferous lining; pistil as long or longer than the stamens; ovary and base of style pubescent.

Fruit oval or subglobose, 1 to 2 cm. long, pubescent, somewhat fleshy while immature, harsh and astringent but with an acid, fruity flavor, opening along suture when mature; stone thick walled, furrowed, with obscure reticulations or smooth or somewhat pitted; kernel in some varieties edible, often strongly flavored with prussic acid.

Two species: *Prunus andersonii* Gray and *Prunus eriogyna*, n. sp.

THE WILD PEACH

The earlier botanical descriptions of the important species *Prunus texana* are so meager that the following description in greater detail seems necessary:

Prunus texana Dietr.[1]

Amygdalus glandulosa Hooker, Icon. Pl., v. 3, pl. 288, 1840.
Prunus glandulosa (Hooker) Torr. and Gray, Fl. N. A., v. 1, p. 408, 1840.
Prunus texana Dietr., Syn. pl., v. 3, p. 45, 1843.
Prunus Hookeri Schneider, Laubhk., v. 1, Lfg. 5, p. 597–598, fig. 335, i, k, l, 1906.
Amygdalus texana (Dietr.) W. F. Wight, Dudley Mem. Vol., p. 131, 1913.
Illus. Hooker, loc. cit.; Schneider, loc. cit.

Low, squarrose shrubs, sometimes reaching a height of 2 meters, with a spread of 2 to 2.5 meters; stems usually slender but occasionally erect and stout branches, rarely spinescent; bark dark iron gray, roughly furrowed on old wood, on young growth grayish brown or silvery gray, densely pubescent.

The leaves, conduplicate in the bud, are usually narrowly elliptical, with rounded apex and rounded or wedge-shaped base; thick, strongly veined, serrate or crenately doubly serrate, with glandular teeth, dull green, thickly pubescent above, canescent beneath, 1.5 to 4 cm. long, 6 to 18 mm. broad; petiole short, rather thick, stipules 3 to 4 mm. long, narrowly lanceolate, with glandular teeth.

The small flowers, which appear with the leaves in February and March, are fragrant, perfect, 1 to 1.5 cm. broad, borne singly or in fascicles of two or three on short, finely pubescent peduncles; the campanulate calyx tube is finely pubescent,

[1] There being a *Prunus glandulosa* of Thunberg, 1784, Hooker's *Amygdalus glandulosa* can not be transferred to the genus Prunus and the name *Prunus texana*, given by David Dietrich (Synopsis plantarum, v. 3, Vimariae, 1843, p. 45), has priority and is a most appropriate one, as this interesting species has so far been found only within the limits of Texas. This conclusion as to the priority of Dietrich's specific name is confirmed and published by Dr. C. S. Sargent in Trees and Shrubs, v. 2, pt. 3, Boston, June, 1911.

the strongly reflexed, short rounded lobes being glandular ciliate margined, with fine soft hairs on both surfaces. The inner face of the tube is lined with an orange-colored, nectariferous layer. The thin white petals, 5 mm. long, are broadly ovate, often truncate at the base, attached by short, stout claws. The ovary and two-thirds of the length of the style are finely pubescent. The fruit is roundish oval or oblong, usually with a ventral shallow furrow, 1 to 2.5 cm. in length, a sharp depression at the base, pedicel 5 to 8 mm. long. The skin is rather thick, coated with fine pubescence, yellowish, greenish yellow, or rarely taking a rich reddish flush on one side; flesh yellowish or greenish yellow, finely netted, juicy and luscious, sometimes very richly flavored, clinging to the rather large stone by a curious tough, persistent elastic pile, like coarse plush, which, when scraped away, leaves an ovate obtusely pointed, thin-walled seed without pits or furrows. The kernel is plump, roundish pointed, slightly furrowed, and with a strong flavor of prussic acid. (Pl. IX, and fig. 3.)

It is plain that with its strongly glandular pubescent leaves and luscious, fleshy fruit with the pilose or velvety stone it has little near relationship with the five species of the group in which it has been included. It has accordingly been placed in the subgenus Euprunus and in a new section, Piloprunus. Analogy for the pubescent fruit is found in the *Prunus oregana* of Greene and for the netted flesh clinging to the stone in the sand plum, *P. watsoni*.

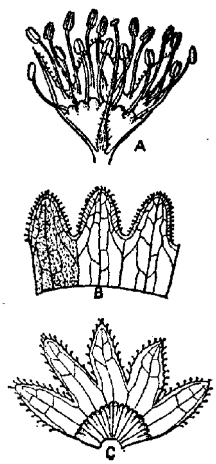

FIG. 3.—*Prunus texana* Dietr.: *A*, Section of calyx, × 3; *B*, detail of calyx lobes, showing glandular margins, × 3; *C*, section of calyx from flower of the horticultural variety Ramsey, *P. texana* × Wild Goose plum, × 4.

With a promising wild species of distinctly limited range it is of first importance to learn under what conditions of soil, temperature, and rainfall it has been able to reach its present standing in the plant world. In a State affording so vast an "open range," so to speak, as the State of Texas, the restriction of a species to a range must mean certain limitations in endurance. If it stops rather sharply as soil types change, with no other apparent reason for not extending farther in that direction, we must suspect a soil preference amounting to limitation. A fairly well-defined northern boundary is pretty sure to mark the limit of cold endurance, provided soil and moisture conditions would seem to invite farther advance in that direction. Therefore, the geographic range or distribution of the wild peach should be studied and also related conditions of soil, temperature, and moisture.

DISTRIBUTION AND SOIL

The range of the wild peach is wholly within the State of Texas, but its local distribution is not yet worked out. As shown by the map (fig. 2), there are two principal areas of its growth. The first of these is what is called the "Burnet Country," a region of granitic uplift occupying the greater portion of Llano County, and small areas of Burnet, San Saba, Mason, Gillespie, and Blanco counties. It is also found along a narrow alluvial strip next to the Colorado River in Lampasas County.

It is upon the sedentary soils from granitic disintegration, small areas from sandstone and schistose rocks of the earlier stratified formations bordering and upturned by the granitic protrusions, and on narrow strips of river alluvium that the "wild peach" occurs. Only one instance is known of its occurrence upon the calcareous areas which surround and in isolated patches overlap the granitic protrusions.

The second considerable area known for this species lies in the southeastern part of Bexar County and in the adjacent counties of Guadalupe, Wilson, and Atascosa, extending eastward into Gonzales and southward into Bee County. As this region is a part of the area of sandstone formation known geologically as the Marine Eocene region and the plants are found only on rather mellow sandy soils, we must conclude that the species has so strong a preference for granitic or sandy soils as to practically exclude it from limestone regions. It was learned in the neighborhood of Lavernia that extensive areas of this "May plum," as it is called in that section, had been destroyed in the clearing up of fields. Isolated patches have been found at points as remotely separated as Van Zandt County at the north, the coast dunes of Aransas County, and a considerable area in the sandhills of Hidalgo County at the south, where the fruit is much esteemed by the Mexicans under the name "durasnillo," or "little peach."[1] It seems probable that a more complete survey of the eastern portions of the State would show that the wild peach has a botanical range extending over a greater portion of the sandy formation of the Marine Tertiary region, restricted probably by lack of moisture in the southwest portion of that formation.

All the plants studied have a deep-rooting habit, enabling them to penetrate to layers of soil where the moisture is fairly permanent as is often the case where the soil has a sandy foundation. This aids them greatly in surviving the long periods of drought to which the country is subject. The thickly pubescent upper surface of the leaves and the almost felted undersurface are features which reduce transpiration and must aid materially in drought resistance.

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[1] Prof. S. W. Stanfield, of the Texas State Normal School, states that in southern Bexar County this fruit is called "albaricoque," which is the Spanish name for the apricot.

CLIMATIC CONDITIONS

The principal areas occupied by *Prunus texana* are represented by fairly complete weather records at Menardville, Fredericksburg, and San Antonio[1] and by volunteer records at Burnet, Llano, and Lampasas.[2] These show that the mean annual rainfall ranges from 22.6 inches in the more westerly to 28 inches in the eastern and southern portions.

The monthly means show a fairly well-distributed rainfall throughout the year. December to March constitutes the drier period, with February as the driest month. The study of the monthly records of a number of years, however, shows that this section is subject to occasional heavy rainfalls almost torrential in character, as well as to periods of severe and prolonged drought. A study of the extremes of rainfall at San Antonio, a nearly central point in the range of this species, shows that during the driest year of the period covered by the record, 1885 to 1903, only 15.9 inches of rain fell, while the maximum record was 40.5 inches. The structural characters enabling *Prunus texana*, the wild peach, to endure these vicissitudes are important features to study.

The temperature conditions characteristic of this section are those of comparatively mild winters, minimum temperatures of 12° to 16° F. being matters of common record, with occasional winters showing minimum records of as low as −2° to −4° F.[3]

Minimum temperatures of 50° to 60° and maximum temperatures of 60° to 75° F. may be followed in a short time by a norther which will lower the temperature to near the zero point, or even below. The extreme maximum temperatures experienced in this section are from 100° to 105° F.

NATURAL HYBRIDIZATION

One of the most striking characteristics of the wild peach is the readiness with which it hybridizes with the native and cultivated plums. This is proved by the occurrence of well-marked natural hybrids with the local wild plums in at least five widely separated localities within its range.

The occurrence of natural hybrids between species of plants is unusual and in many families rare or unknown. The integrity of our plant forms could not be preserved if indiscriminate natural hybridizing were a possibility.

Probably among trees and shrubs the most numerous examples of such hybrids are afforded by the oaks of the Mississippi Valley and the Western States, and a number of these have from time to time received definite

[1] Henry, A. J. Climatology of the United States. U. S. Dept. Agr., Weather Bur., Bulletin Q., p. 431–436, 1906.

[2] U. S. Dept. Agr., Weather, Bur., Climate and Crop Service, Texas Section, v. 1–5, 1897–1901.

[3] There was a record of −4.1° F., at Llano, Feb. 12, 1899. U. S. Dept. Agr., Weather Bur., Climate and Crop Service, Texas Section, Report, v. 3, no. 5, p. 5, 1899.

botanical description. A few wild grape hybrids are recorded in the writings of Dr. Engelmann.

Among plums a few definite natural hybrids of the wild species have been recognized, and the later judgment of Prof. Bailey on *Prunus hortulana*, described by him as a species, is that it is a group of varieties which are hybrids between *Prunus americana* and the southwestern species, *Prunus angustifolia*.[1]

On the whole, surprisingly few authentic hybrids have come into existence without the aid of man among uncultivated plants.

Examples of natural or unassisted hybridization among cultivated plants are somewhat more common, as though as a result of cultivation some of the safeguards which nature had established against the interbreeding of species had been broken down, but here again the sum total of such crosses is small.

These considerations make it the more interesting and significant when we find such a divergent form of plum as this so-called wild peach hybridizing so freely with the local forms with which it comes in contact.

How numerous these hybrids may actually be is only a matter of conjecture, and only a close survey of the entire region of occurrence of *Prunus texana* can disclose this. The detection of these at any stage of active growth is rendered comparatively easy by the strongly marked characters of this species. The narrow, pubescent, strongly glandular-serrate leaves, as well as the pubescent calyx cup with glandular-serrate lobes, added to the notable character of the pubescent fruit with its peculiar pile-covered stone, all help to render one of this class of hybrids conspicuous and unmistakable. Three of the more striking forms in three widely separated localities had been noticed and taken into cultivation years ago by observant ranchmen interested in fruit growing. Systematic search by the writer and other observers, though for only a few days and over a very limited area, disclosed the other eight recorded.

It is significant that in five out of seven of the most important regions where the wild peach is associated with the wild species of plums these spontaneous crosses have been found. In these same sections hybrid forms between the numerous species of true plums are rare or have not been detected. More conclusive evidence can hardly be offered that *Prunus texana* crosses with a number of species of the true plums with unusual readiness, far more readily than these species cross among themselves. It is on account of this fact and the promise which it holds out to enterprising plum breeders that it has been thought worth while to describe in rather minute detail a number of these natural hybrids, including several which as horticultural varieties have little or no value.

The first of these varieties was learned of during an exploring trip around Kingsland, Llano County, in March, 1910, and through the kind-

[1] Willard, S. D., and Bailey, L. H. Notes upon plums for western New York. New York Cornell Agr. Exp. Sta., Bul. 131, p. 170, 1897.

ness of Mr. Henry Smith the writer was shown a group of bushes located on the Smith ranch near the foot of Pack Saddle Mountain, about 6 miles from Kingsland. These had been known to a few settlers in the neighborhood for many years and the fruit had been carefully gathered on account of its value in making preserves and jam. The "Llano" variety, named and propagated for distribution by Mr. L. Miller, a nurseryman at Lampasas, was secured in this neighborhood and is so nearly identical with those seen on the Smith ranch that a separate description is scarcely necessary.

The next group was located near the south line of Llano County not far from the Llano and Fredericksburg Road. Mr. F. M. Ramsey had previously discovered a bush in this region which from its appearance he believed to be a hybrid of the wild peach and a plum. On a trip with the writer in search of this plant two more were found in the same neighborhood. These are described in succeeding pages under the names "Willow," "Sumlin," and "Holman." They are of considerable interest as botanical hybrids showing the potency of the species *Prunus texana* rather than for the quality of the fruit produced.

Having been informed that at Valley Springs, about 12 miles northwest of Llano, a farmer had wild peaches growing in his garden and that with cultivation they grew as large as plum trees, another group of hybrids was suspected. A visit was accordingly made to the farm of Mr. N. F. Gephart, an early settler in the Valley Springs district, in whose orchard several plum trees just ripening fruit were found to show undoubted evidence of *Prunus texana* origin. Yet three clearly distinct varieties could be detected. The two which are described as the "Gephart" and the "Johnson" are interlocking trees which Mr. Gephart states he found in a wild state in clearing the ground for the orchard more than 20 years ago.

The history of the Bolen variety, with two or three others in the garden, is rather obscure. Mr. Gephart states that there used to be a tree of this character, long since disappeared, on a near-by farm known as the Bolen place. He is of the impression that seeds from this original Bolen fruit were planted in his garden and produced one or more trees, which bore well for a number of years but are now dead. There are at present several trees very similar in character. Whether they are from sprouts of the original seedlings of the Bolen tree or from a second generation of seedlings Mr. Gephart is uncertain. Apparently the first cross of *Prunus texana* was the original tree on the Bolen farm, from which the seedlings in the Gephart garden originated.

The following year, 1911, information was received of "a plum with a skin like a peach" growing in an orchard near Lavernia, Wilson County, 20 miles southeast of San Antonio, and on a visit to that place two small trees were found on the farm of Mr. W. J. Stuart, who reported that he had found a little group or thicket of these trees in a draw when clearing

part of his farm. These two had been transplanted to his plum orchard and the others grubbed up. Though not perfectly identical, these trees—though small, they were perfect trees in form—are so similar as to make it superfluous to give separate descriptions. The more perfect of these was selected for description and named "Stuart" for the owner. (Pl. X, figs. 1 and 2.) Its fruit is among the best produced by hybrids. Two points worthy of note about this variety are that the flowering followed the opening of the leaves and that there is a tendency to suckering or root-sprouting.

A few days later, in a trip along the Hilderbrand Road in company with Mr. R. E. Blair, two more hybrid varieties were found in a field of the Whittaker Ranch. Both were small trees, evidently sprouted from an older growth broken down. The flowering season had passed and a small setting of half-grown fruits was noted. Later in the season Mr. Blair returned and found a few of these ripe, but a detailed description was not secured. It is a medium-sized, dull-red fruit of only fair quality. The variety near the fence on the pike road was designated as the Hilderbrand and the one in the field as the Whittaker. On a later trip Mr. Blair located another hybrid tree in the same neighborhood, a detailed description of which has not been secured.

It will be noticed that in the descriptions of these hybrids no attempt has been made to name other parents than the wild peach (*Prunus texana*), which dominates them all. There are characters which indicate that at least three other species as parents must be reckoned with. The northern portion of the range of this species is also the home of a number of species of typical American plums.

Prof. Sargent has but recently described two new species from this territory, and it is probable that others are pending. No less than eight species of Prunus of the plum class have been credited to this territory, several of which are with difficulty distinguished from each other. The hopelessness of determining the other parents of these hybrids is immediately apparent. We have no basis for more than a conjecture as to which direction the cross may have taken, whether *Prunus texana* furnished the pollen or was the pistillate parent.

The only hint we can get in this direction is from the work of Mr. Ramsey, referred to later. He made use of pollen from the Wild Goose plum, without removing the stamens from the flowers of the wild peach and secured four hybrid trees out of a number of fruits set on the protected branch. All of these four show Wild Goose characteristics in their flowers.

The grouping of a number of closely similar varieties, as in the case of the two Gephart trees, the Stuart group, and those on the Hilderbrand Road, suggests that a bush of wild peach may have received visits of bees carrying wild-plum pollen and that a number of fruits of this pollination germinated under or near the parent bush.

DESCRIPTIONS OF HYBRIDS

Prunus hortulana (Wild Goose) × **texana.**

Hort. var. Ramsey.

A rather ragged branched tree about 2 meters high, with yellowish brown pubescent twigs of new growth. Leaves ovate lanceolate, acuminate at apex, rounded or broadly cuneate at base, serrate or doubly crenulate serrate, with short glandular teeth; upper surface dull with scattered short hairs; lower surface grayish green, silvery tomentulose; petiole stouter than in most of the hybrids, 5 mm. to 10 mm. long, tomentose; stipules narrow, acute, glandular toothed.

The flowers, which appear before the leaves, about the middle of March, are white, about 8 mm. broad, borne in three or four flowered umbels on slender, pubescent pedicels. The calyx is pubescent, lobes pubescent on both surfaces, margins glandular.

The fruit, ripe about June 15, is globose, 2 to 2.5 cm. long, the rather thick dull-red skin sparingly tomentulose, the thin reddish flesh clinging to the velvety coated pit, which is turgid, oval, pointed at either end, and with a broad ventral ridge; the pedicels are 8 to 10 mm. long and stouter than in most of the hybrids of the species. This fruit is acid, rather austere, but of value in making jellies, marmalades, etc. The originator, Mr. Ramsey, states that it is a remarkably regular bearer. It seems to thrive well on a strongly calcareous soil and has been grown to a good size worked on peach stock.

Prunus texana hybrid.

Hort. var. Llano.

A low, ragged bush, 1 to 1.5 meters high, as it occurs in thickets in the stony pastures in Llano County, where it was first observed more than 30 years ago and where it spreads slowly by means of root sprouts. Worked on peach stock the twigs of young growth become long, slender, and pendulous with little disposition to spiny branches. The twigs of young growth are reddish brown, thinly pubescent.

Leaves elliptical or ovate elliptical, apex acute or narrowed and shortly acuminate, base rounded or broadly cuneate; margin serrate or doubly serrate; the teeth glandular tipped; the upper surface dull green, with scattering short silvery hairs; russety green with thin pubescence beneath; 3.5 to 4 cm. long, 1.5 to 2 cm. broad; the midribs yellowish brown; slender petioles about 7 mm. long; stipules 3 to 5 mm. long, narrow, acute, coarsely glandular toothed. The flowers appearing with the leaves are white, 5 to 8 mm. broad; calyx tube campanulate, pubescent; lobes short, broadly ovate, with glandular teeth and hairy inner surface; petals obovate with short claw.

The fruit, ripening in June, is globose, a little compressed, 2 cm. in diameter; color dull red; skin rather thick, coated with a thin, fine pubescence; flesh netted, clinging to the pit, which is turgid; oval, obtuse at base and apex, coated with velvet pile; pedicel short. This fruit, produced in great abundance, is of a sharply acid flavor, but is highly esteemed for domestic use.

Prunus texana hybrid.

Hort. var. Willow.

A willowy shrub, 1 meter high, profusely branched, the branches angled at nodes, long, slender, tapering; young growth greenish brown, pubescent, but becoming smooth iron gray with age.

Leaves ovate lanceolate; apex acute; base rounded; margin finely and evenly glandular serrate; upper surface dull green with scattered hairs; under surface grayish green with a thin silvery pubescence; 3 to 4 cm. long, 1.5 to 1.7 cm. wide; venation prominent; petioles 4 to 5 mm. long; pubescent; fruit solitary as far as seen, a small roundish plum with the surface covered with scattering hairs; stalk 3 to 4 mm. long; not seen in mature condition. While an evident hybrid with distinct plumlike

characters, this variety retains more of the *Prunus texana* characters than any other hybrid noted. But one plant discovered, south of Big Sandy Creek, Llano County, Tex.

Prunus texana hybrid.

Hort. var. Sumlin.

An erect, slender-branched shrub, with grayish brown bark on old wood and slender, yellowish brown pubescent twigs of young growth.

Leaves ovate elliptic, acute at apex, rounded or broadly wedge-shaped at base, serrate with glandular teeth; the upper surface dull green, with short scattered hairs; lower surface grayish green; hairy tomentose; 4 to 5 cm. long; midrib rather conspicuous; petiole short; stipules 3 to 4 mm. long, narrow, acute, glandular toothed.

Fruit a small, roundish, pubescent-coated plum, upon a stalk 4 to 10 mm. long. Not seen mature, but described as red in color and a desirable fruit, ripening somewhat later than the *Prunus texana* parent. Some of the characters in this variety suggest that the cross may have been derived from a local wild plum usually classed as *P. americana* var. *lanata* Sudworth, though perhaps an undescribed species. Trees of this form occur in the same field and, while flowering a little later, overlap *P. texana* in blooming period.

Prunus texana hybrid.

Hort. var. Holmann.

An erect-growing shrub 1 to 2 meters high, of irregular branching habit, inclined to be spiny. Young growth slender, yellowish brown, with thin pubescence; older wood iron gray.

Leaves 3 to 5 cm. long, 1.5 to 2 cm. broad, ovate lanceolate, with rounded base and acute apex; margin finely glandular serrate; upper surface with scattered short hairs; lower thinly pubescent; petiole 4 to 6 mm. long.

Fruit a small oval plum with a thinly pubescent surface, borne singly or in pairs; stalk 6 to 10 mm. long; calyx sometimes persistent. Described as being of poor quality. Found in a scattering group of small thickets, indicating that it has ability to spread by root sprouts.

Prunus texana hybrid.

Hort. var. Gephart.

A tree 2.5 meters high, with numerous slender semipendulous branches; young growth reddish brown, finely pubescent; older wood silvery gray or iron gray.

Leaves narrowly elliptical, approaching oblong; apex rounded or acute, finely doubly serrate with minute glandular teeth; base rounded or broadly wedge shaped; upper surface dull green, covered with scattering short hairs; lower surface ashy gray green, finely reticulated, silvery pubescent; 3 to 4 cm. long; stipules 2 to 3 mm. long, slender, acute, glandular toothed.

Fruit borne in great profusion, smooth, plumlike in appearance, oval, 2.5 cm. long, dull yellow, with slight pubescence; stalk 3 to 5 mm. long; a juicy fruit, the rather soft flesh clinging to the pilose pit much as in the original species, somewhat subacid and lacking in quality. The earliest ripening of any of the *Prunus texana* hybrids so far noted (May 13 to 18).

Prunus texana hybrid.

Hort. var. Johnson.

This variety was found growing interlocked with the Gephart, but is more upright and stiff branched in habit and quite distinct. Young twigs reddish brown, slightly angled at the nodes, sparingly pubescent; older growth grayish brown or iron gray. (Pl. X, fig. 3.)

Leaves narrowly elliptical or obovate elliptical, rounded at the apex, rounded or tapering at the base; margin finely doubly glandular serrate, dull pale green set with scattered hairs above, ashy green, thinly pubescent beneath, 3 to 4.5 cm. long, 1 to 1.5 cm. or, rarely, 2 cm. broad; the midribs and slender petioles, which are 1 to 2 cm. long, are dull purplish; stipules 2 mm. long, slender, acute, glandular toothed.

Flowers not seen.

Fruit in close bunches, single or paired, 2 to 2.3 cm. long, oval, slightly compressed, covered with a fine, soft pubescence; stalk slender, 1 cm. long, pubescent, inserted in a very slight depression. Skin dull greenish yellow, tough; flesh greenish yellow, acid, flavor better than that of the Gephart, but not a fruit of high quality; stone oval, flattened, acute at apex, having a soft, short, velvety pile of the *Prunus texana* type.

Prunus texana hybrid.

Hort. var. Bolen.

A compact, pendulous-branched tree, about 2.5 meters high, with finely pubescent, brown twigs of young growth.

Leaves broadly elliptical, narrowing abruptly to an acute apex; base rounded or broadly wedge shaped; margins finely glandular serrate, upper and lower surfaces with scattered silvery hairs, scarcely amounting to a pubescence, 4 to 4.5 cm. long, 2 to 2.5 cm. broad, the yellowish brown midrib passing into a slender hairy petiole, 5 to 7 mm. long.

Fruit 2.5 cm. long, 1.5 to 2 cm. broad, oval, slightly oblique, and tapering to an obtuse apex; stalk about 5 mm. long, a little stouter than in the Gephart variety. Skin dull yellow, rather tough; flesh yellow, rather thin because of the large seed; flavor very similar to that of the pure *Prunus texana* species.

Prunus texana hybrid.

Hort. var. Stuart.

A small tree with trunk 1 cm. in diameter and spreading top 2.5 meters high and 3 meters broad; branches angular but smoother and more open than in *Prunus texana;* bark grayish brown. The trees show some tendency to spread from root sprouts.

Leaves ovate elliptical, rounded or broadly pointed at apex; cuneate at the base; serrate or doubly serrate, with fine glandular teeth; dull green with fine scattered hairs on the upper surface; grayish green, finely pubescent beneath; 3 to 3.5 cm. long; a conspicuous midrib passing into a short, dull red petiole; stipules minute coarsely glandular toothed.

The flowers, which appear later than the leaves, borne singly or two or three in a fascicle, are about 6 mm. in diameter, on slender hairy pedicels from 4 to 8 mm. long; calyx tube narrowly campanulate, surface sparsely covered with short hairs; lobes elliptical, with scattered glandular teeth and fringed with fine hairs; inner surface with scattered hairs; petals thin, white, broadly obovate, with a short claw; ovary velvety pubescent, but style smooth. Mature fruit oval, about 2.5 cm. long, with an acute cavity around the short stalk; dull yellow, with velvety surface and mellow, luscious, highly flavored flesh. Seed oval, turgid, with heavy velvety pile.

Prunus texana hybrid.

Hort. var. Hilderbrand.

A small tree with slender, erect, rather angular branches; bark smooth, grayish. Leaves obtuse or rounded at the ends; finely, sometimes doubly, serrate, with minute glandular teeth; dull green, with scattered fine hairs on the upper surface; grayish green with hairs more numerous below; 3 to 3.5 cm. long, 0.7 to 1 cm. wide; midrib narrow, tinged with dull purple at the base; petiole short, slender, pubescent; stipules 2 mm. long, narrow acute, glandular serrate.

Flowers not seen, apparently opening with the leaves.

Fruit oval, velvety, stalk 1 cm. long, slender, nearly glabrous. (Mature fruit not seen; described as being red.)

Prunus texana hybrid.

Hort. var. Whittaker.

A shrub of treelike form, 2 meters high; branches regular or somewhat angled at the nodes, long, slender, with few spines; bark smooth, iron gray or brown.

Leaves thin, narrowly elliptical, acute at both ends, doubly serrate with minute glandular teeth; dull green with minute scattered hairs above, grayish green, more abundantly hairy below; 4 to 5 cm. long, 1 cm. to 1.3 cm. broad; petiole slender, pubescent, dull purple, 0.5 to 1 cm. long; stipules lancelinear, acute, glandular serrate, about 2 mm. long.

Flowers, appearing with the leaves, small, on slender hairy peduncles about 6 mm. long (petals not seen); calyx tube narrowly elliptical, fringed with fine silvery hairs and sparsely coated with hairs on the inner surface.

Fruit borne singly or in pairs, oval, finely pubescent (not seen mature; color said to be red), the pubescent stalk 6 to 8 mm. long.

THE NEVADA WILD ALMOND

The wild almond (Pls. XI and XII, figs. 1 and 2), the most striking of all the dry-fruited members of the plum family occurring in the United States, was first described by Asa Gray from specimens sent him by Dr. C. L. Anderson, collected near Carson, Nev., 1863–1866, and was named in honor of Dr. Anderson.

From field notes and abundant herbarium material collected by the writer in person or supplied by Mr. E. W. Hudson, important characters heretofore unnoted are brought out and this species is redescribed as follows:

Prunus andersonii Gray.

Prunus andersonii Gray, Proc. of Amer. Acad., v. 7, p. 337-338, 1868.
Amygdalus andersonii (Gray) Greene, Fl. Franc., pt. 1, p. 49, 1891.
Emplectocladus andersonii (Gray) Nelson and Kennedy, Muhlenbergia, v. 3, p. 139, 1908.
Illus., Schneider, C. K., Laubhk., p. 598, fig. 335, d, e.

A spiny, much-branched, interlocking shrub 1 or 2 meters high, or, rarely, more smooth, erect, and treelike, reaching 3 meters or over; bark of young branches grayish green to reddish or yellowish brown, glabrous, on older wood breaking into coarse, dark-gray scales. The leaves are convolute in the bud, broadly or narrowly spatulate, with rounded or acute apex and short petiole, finely serrulate or entire, often with a pair of small glands near the base, 1 to 4 cm. long; yellowish or grayish green, leathery, glabrous, or faintly pilose at the base; stomates present in the upper epidermis.

The flowers, appearing with the leaves, are perfect, 1.5 to 2 cm. in diameter, on slender glabrous pedicels, 1.5 cm. or less in length, solitary or fascicled; calyx tube short, campanulate, leathery, glabrous, or rarely with pedicel and calyx cup puberulous; lining nectariferous; the lobes triangular with ciliate margins, often persistent on mature fruit; petals from pale to deep-rose color, or rarely white, oval, 6 to 10 mm. long, narrowing abruptly to a short claw; stamens 20 to 30; style equal to or longer than the stamens; glabrous or only the lower one-fourth hairy; ovary pubescent.

Fruit roundish or obliquely unsymmetrical, compressed, often with a marked winglike ventral expansion, abruptly rounded to an apiculate apex; base distinctly

necked, 1 to 1.8 cm. long, dull grayish or greenish yellow with thickly pubescent surface, usually with prominent, coarse, reticulate venation as it dries; the thin flesh dry, leathery, and astringent, or, rarely, more succulent and with edible qualities, usually splitting along the ventral suture at maturity after the fashion of an almond.

Stone roundish, unsymmetrical, turgid or compressed, the narrow dorsal wing having a shallow groove; the ventral wing often much expanded; has an acute central ridge usually flanked by parallel ridges and obscure reticulate veins; surface smooth

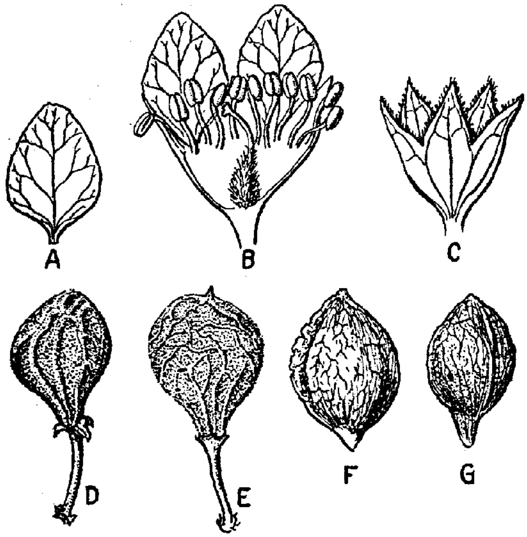

FIG. 4.—*Prunus andersonii* Gray: *A*, Petal, × 3; *B*, section of a flower, × 3; *C*, calyx showing ciliate margins, × 3; *D*, *E*, dried fruit 1½ times natural size; *F*, *G*, stone, 1½ times natural size.

or obscurely or decidedly pitted; apex rounded to an acute point, base with a more or less thin, attenuated neck; kernel small, pointed, grooved in some varieties, edible, often strongly flavored with prussic acid. (Fig. 4.)

This species is one of the most distinctive of those commonly included in the Emplectocladus group.

On mountain sides and dry foothills of eastern California and Nevada it is a squarrose, much-branched and spiny shrub, 1 to 2 meters in height and diminishing to 0.5 or 0.7 meter at its upper limit of growth. In more favorable situations, along the shore of Pyramid Lake and other localities where better soil and a more constant supply of water occur, it becomes a large shrub or even a small tree. Forms appear reaching over 3 meters in height, nearly free from spines, with clean, free growing branches and have the appearance of young peach or almond trees. (Pl. XII, figs. 1 and 2.) Well-marked varietal forms are found, not only

in habit of growth and branching, and color and texture of bark, but in size and color of flowers and character of fruit.[1]

One variety was noted with fruits of unusual size and having a fleshy development of the pericarp instead of the characteristic dry, leathery coating.

A very strongly developed taproot is a characteristic of this species as well as of several others of the group. This has been very noticeable in growing seedlings. Seeds stratified in sand and exposed to open conditions of a severe winter of Washington, D. C., made a vigorous germination early in March, sending down strong taproots, while the tops were but two or three leaves above the ground. This must be recognized as an adaptation which has enabled them to survive under peculiar local conditions. Where wild-almond thickets occur there can usually be traced at a depth of 1 or 2 meters a layer of soil or sand where more permanent moisture is afforded than prevails near the surface. After the taproot has penetrated this layer small branches spread out into it and the moisture made available enables the plant to survive drought and heat which would have caused it to perish if supported by superficial roots.

The range of occurrence of this species is shown on the map (fig. 1) and is a region of such scant rainfall that little agriculture is possible without irrigation. Taking Carson City, Nev., as a typical station,[2] the mean annual precipitation is slightly above 10 inches, falling as low as 5 inches in years of extreme drought. The 2 feet or more of snow forms a considerable portion of the annual moisture, the mean precipitation from April to September, inclusive, being but 2.4 inches. With summer heat occasionally reaching 100° F., and the average winter temperatures of −20° F., some idea of the hardiness and drought resistance of this species can be formed.

THE DESERT APRICOT

This striking apricotlike species occurs only in certain out-of-the-way places in southern California. (Pls. XII, fig. 3, XIII, and XIV, fig. 1.)

Confined chiefly to a narrow zone on the desert side of the San Bernardino and San Jacinto Mountains, the only frequented spots of its habitat are the village of Palm Springs at the foot of San Jacinto Peak on the south and the almost deserted hamlet of Banner at the foot of the mountains and just above the border of the desert below Julian in San Diego County.

In the Gray Herbarium the type specimen sheet has mounted upon it a specimen bearing the label "*Prunus subcordata*, Bth.," and in print,

[1] Mr. E. W. Hudson, of the Office of Crop Physiology and Breeding Investigations, while doing cooperative work at Wadsworth Agency, made numerous collections of this species in 1910 and noted that the flowers ranged in color from pale pink to a deep-rose color, and also varied greatly in size.

[2] Henry, A. J. Climatology of the United States. U. S. Dept. Agr. Weather Bureau, Bulletin Q, p. 920, 1906.

"Flora of Southern California, &c. Coll. by C. C. Parry and J. G. Lemmon, 1876." In the upper right-hand corner of the same sheet is a specimen of very different appearance bearing the label, "Fremont's Expedition to California, 1845–7. 370—1846," and in pencil "New" (in the hand of Dr. Asa Gray). At the bottom of this sheet is the penciled label "*P. Fremonti* Watson, n. sp."

The specimen first cited and referred to as collected by Cleveland in Oriflamme Canyon bears the label "*P. subcordata*, var. *eriogyna*," but it has also beneath a subsequent label the penciled inscription, "*P. Fremonti* Watson, n. sp."

It has been noted by Mr. W. F. Wight, of the Bureau of Plant Industry, in a memorandum placed upon the specimen in 1910, that the Frémont specimen is *Prunus subcordata*, a determination supported by the glabrous pistils and the leaf characters.

Dr. Watson clearly had before him three specimens upon which he based his description of the new species and to which he attached the name. While he cites the Frémont specimen last we may readily presume that it was because of its lacking a definite locality label, which the first and second citations possessed. Having incorrectly included it in the type material, however, and having given the name "*Fremonti*" to the species, this specimen, according to the American Code of Botanical Nomenclature (section 4, canon 14, a), becomes the type specimen. *Prunus fremonti* Watson, then becomes a synonym of *P. subcordata* Benth., leaving the species bordering the Colorado Desert unnamed. The name *Prunus eriogyna* is accordingly proposed for this species.

These two species seem to have been subject to much confusion by the earlier collectors.

Dr. Torrey in the Botany of the Mexican Boundary Survey[1] refers specimens collected by the expedition at San Felipe to "*Prunus subcordata*, Benth., Pl. Hartw.," yet his description tallies well with *P. eriogyna*, and the San Felipe locality renders it probable that he had this species before him.

The specimen collected by Frémont is undoubtedly *Prunus subcordata* Benth., the type of which was collected by Hartweg somewhere about the upper waters of the American River in the latter part of April, 1846.[2]

By an interesting coincidence Col. Frémont in his Memoirs, p. 476, mentions camping March 26, 1846, at the ranch of the same Mr. Cordua where Hartweg made his headquarters in the Sacramento country. The month of April Frémont spent in the region tributary to the Sacramento River, now included in Butte, Tehama, and Shasta Counties,

[1] Torrey, John. Botany of the boundary. Emory, W. H. Report of the United States and Mexican Boundary Survey . . . v. 2, Washington, 1859, p. 63.

[2] Hartweg, T. Journal of a mission to California in search of plants. Jour. Roy. hort. soc. [London], v. 3, p. 221, 1848.

and the date of Hartweg's collection, made at a considerable altitude in the foothills, suggests the probability that the Frémont specimen was secured in the upper waters of one of the many mountain tributaries which he visited.

From abundant material collected near Palm Springs and in the Banner Canyon of San Diego County and from field notes covering several seasons' observations the following detailed description of this new species has been drawn.

Prunus eriogyna, n. sp. (Fig. 5.)

Prunus fremonti[1] S. Watson, in California, Geological Survey, Botany, v. 2, Cambridge (Mass.), p. 442–443, 1880.

Amygdalus fremonti (S. Watson) Abrams, in Bull. N. Y. Bot. Gard., v. 6, no. 21, p. 385, Sept., 1910.

Illus., Schneider, C. K., Laubhk., Lfg. 5, p. 598, fig. 335, u, v.

A spiny, intricately branched and angled shrub reaching 4 meters in height. Twigs of young growth glabrous, bright reddish brown, becoming silvery gray or brown with age. Bark on old stems black, breaking into thin plates or scales.

Leaves variable, lanceolate, ovate or orbicular, or sometimes broader than long, rounded or cordate at the base, narrowing abruptly to a short acute apex or often rounded or obtuse; glandular denticulate, usually with one or more larger glands near the base or rarely on the petiole; both surfaces pale grayish green, shining above, firm, sometimes leathery; midrib and veins prominent on under surface; stomates in both upper and lower surfaces; 1.5 to 3 cm. long, 1.5 to 2.5 cm. or more broad; petiole 6 to 8 mm. long; stipules minute, narrowly acuminate, glandular denticulate.

The perfect flowers, borne in small umbels and having a faint, agreeable odor are produced in great profusion, appearing from January to March, according to rainfall, when the leaves are partially developed. In bud they are white, salmon, or rose pink. Expanded they are usually 6 to 8 mm. in diameter, reaching 18 mm. in some forms, on slender pedicels 6 to 12 mm. long; calyx tube short, campanulate; outer surface glabrous or thinly pubescent; inner covered with a salmon or rose colored pigment; lobes oval, half as long as the petals, finely pubescent on inner surface, glandular ciliate, often hanging loosely in a dried condition around the pedicels of the mature fruits; petals white, pink, or rose, 3 to 6 mm. long, oval, incurved at apex, base rounding to a stout claw; stamens about 24 to 30, many imperfect; ovary and lower portion of the style finely pubescent; stigma but little expanded.

The fruit, which ripens in May, is in appearance a small apricot, 1 to 2 cm. long, subglobose, ovoid or oblong ovoid, sometimes oblique, slightly or decidedly compressed; apex mucronate; skin puberulent, dull yellow or greenish yellow, often with a dull-rose flush, with a well-marked ventral suture along which the thin astringent flesh opens in ripening, sometimes allowing the stone to drop, while the desiccated flesh remains attached to the peduncle; stone smooth or slightly roughened, usually flattened or somewhat turgid, obtuse at both ends with a well-marked dorsal furrow and a thick ventral expansion along the middle of which is a low, acute ridge separated by smooth, narrow furrows from two obtuse parallel ridges; often one or more pairs of obscure veins extend from the base and branch along either side; stony walls thick,

[1] "*P. Fremonti.* A spiny glabrous densely branched shrub or small scraggy tree (15 feet high) with short branchlets: leaves small (4 to 8 lines long), thin, ovate or roundish, on short slender petioles, denticulate: flowers appearing with the leaves, solitary or somewhat fascicled, 5 or 6 lines broad, on pedicels 2 or 3 lines long: calyx lobes ciliate: ovary densely pubescent; style elongated: stone oblong, turgid, rounded on one side and with a broad ridge upon the other, 5 lines long.

"Coast Ranges of Southern California, Oriflamme Cañon, San Diego County (*D. Cleveland*); San Bernardino Mountains, *Parry & Lemmon*, n. 108, 1876. Also collected by *Fremont* in 1846, locality uncertain. Flowering in March; fruit probably with little pulp."

kernel small, strongly flavored with prussic acid. Type specimen in United States National Herbarium, C. P. B. No. 1155. Merotypes cut from the tree that yielded the type specimen have been sent to a number of other herbaria.

The type locality of *Prunus eriogyna* is along the watercourse in the boulder talus at the mouth of Tahquitz Canyon at the southern base of the San Jacinto Mountain, near Palm Springs, Riverside County, Cal. It is also found on dry talus slopes in Andræas, Murray, and Palm Canyons, along the trail to Van Deventer Flats below Santa Rosa Peak, and up the rocky slopes of the San Jacinto Mountains to an altitude of over 2,000 feet, growing in barren soil and crevices of rocks, being apparently extremely xerophytic. Its range is from the southern slopes of the San Bernardino Mountains southward along the desert slopes of the San Jacinto Mountains to San Diego County, and into Lower California.

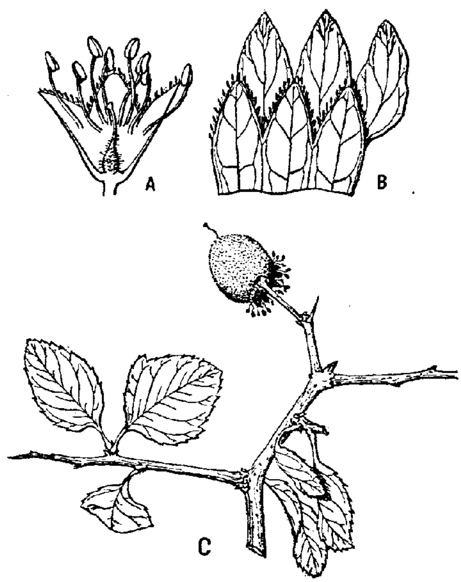

FIG. 5.—*Prunus eriogyna*, n. sp.: *A*, Section of calyx, × 3; *B*, detail of portion of calyx with petals, from outside, showing glandular ciliation of lobes, × 3; *C*, twig showing angular habit of branching, leaves and fruit attached, ¾ natural size.

The plumlike appearance of the wood, especially of the younger growth, and perhaps a sprinkling of roundish or oblong green pubescent-coated fruits, would excite an inquiry that would bring out the names "desert almond" or "wild apricot."

ADAPTATION TO DESERT CONDITIONS

The adaptations of *Prunus eriogyna* to the peculiar conditions which prevail on the desert slopes of mountains are worth noting. The rainfall, slight as it is, really governs plant activities, and vegetation becomes most nearly dormant during the summer months. The rains consist of rare torrential downpours in August and light rains from October to May, but are nearly confined to the period from December to March, the entire volume ranging from less than an inch to 9 inches and a fraction annually. With warm winter days and the temperature at night falling but little

below freezing the vegetative activity in many species of plants that have become dormant during summer drought may be resumed at any time when a sufficient supply of water is afforded.

In the case of *Prunus eriogyna* a copious November rain may start the favorably located bushes into activity, so that a small percentage of the many flower buds will open in January. Cool nights and light frosts may destroy a portion of these buds, but some will set fruit, indicating a fair degree of hardiness for this species. At the time of the main flowering in March there may be a few scattering, nearly mature fruits, which escape the numerous plum curculios and furnish a small supply of seeds for germination should the rainfall be inadequate to mature the main crop of fruit.

In seed germination this species differs strikingly from ordinary apricots or plums. Germination is rapid, the plants appearing above the ground in from 8 to 10 days. As an example, in a pot of seeds sown in sandy soil in a greenhouse on July 31 a number of plants were above the soil on August 6. One with the plumule 1 cm. long had already sent down a taproot of 9 cm. In desert conditions with fruit ripened in May germination is necessarily deferred till the autumn or winter rains set in, when the quick germination habit is essential to its success. Getting its roots down to a zone of permanent moisture, however slight, is the necessary thing if the seedling is to survive the dry, hot summer that follows. A sufficient leaf expansion to afford the needed root growth is all that is necessary and more would only hasten transpiration and waste the limited supply of moisture.

That even the best forms of *Prunus eriogyna* are far from having the quality of cultivated apricots is evident from the appearance of the plants, but that this desert species of the Pacific slope has very close affinities with the true apricot of the Orient can not be doubted. The apricot relationship of *P. andersonii*, with which is placed *P. eriogyna*, is not so evident, yet its convolute leaves, fascicled flowers, and slender-stalked fruit with a slight tendency to be fleshy will ally it to the *Prunus dasycarpa* type of the apricot more nearly than to the almond.

THE CALIFORNIA DESERT ALMOND

The desert almond, also called the "wild peach" and "wild almond," occupies a range much farther south and east than that of the Nevada wild almond, *Prunus andersonii*. It overlaps the southern range of *P. andersonii* in Nevada and eastern California and that of *P. eriogyna* in southern California. It has been collected near the coast in San Luis Obispo and Santa Barbara Counties and as far east as southwestern Utah and northwestern Arizona. Its greatest abundance as far as studied is along the foothills bordering the Mohave Desert in the neighborhoods of Hesperia and Neenach at altitudes of 3,000 to 3,500 feet. The soils

it favors seem to be from decomposed granite or mica schist. In washes where the sands and silts from these rocks are deep an enormous root development is made, the plants forming dense thickets of many sprouts, reaching 7 or 8 feet in height. On granitic slopes above the washes the plants occasionally grow with a single stem and a miniature tree-like form (Pl. XIV, fig. 2). The following description of this species is the result of examination of many plants in the field and the study of abundant herbarium material.

Prunus fasciculata Gray. (Fig. 6.)

Emplectocladus fasciculatus Torr., Pl. Frémont, p. 10–11, pl. 5, 1853.[1]
Prunus fasciculata Gray, Proc. of Amer. Acad., v. 10, p. 70, 1875.
Amygdalus fasciculata Greene, Fl. Franc., pt. 1, p. 49, 1891.
Illus., Schneider, C. K., Laubhk., Lfg. 5, p. 598, fig. 335, f, g, h; Torr., loc. cit.

A much-branched, scarcely thorny shrub, with many small branched stems from a common crown or rarely with a single stem and short stiff branches, usually 1 or 2, rarely 3 meters high, with stems 6 to 10 cm. in diameter at the base.

The bark on young twigs is usually puberulous or pubescent, at first pale green, darkening to reddish or silvery brown, with conspicuous lenticels; dark gray brown or nearly black on older wood.

The leaves, conduplicate in vernation,[2] are borne singly on young wood of free growth, but are fascicled on short budlike suppressed branchlets on older growth. They are narrowly linear spatulate with a mucronate apex and cuneate base; margin entire or with a few fine serrations; blade thin, pale green, puberulous above and below; 1 to 4 cm. long, 3 to 7 mm. broad; petiole short or wanting; stipules caducous, slender, attenuate, minutely glandular.

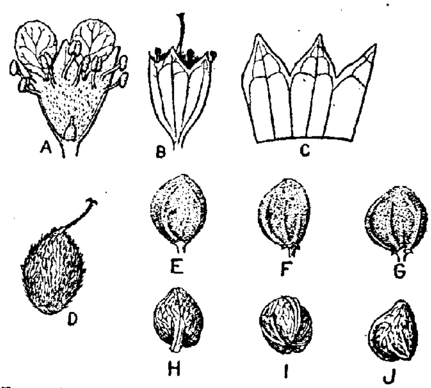

FIG. 6.—*Prunus fasciculata* Gray: *A*, Section of staminate flower, showing abortive ovary and minute hairs on interior of calyx, × 3; *B*, calyx cup, pistillate form, showing abortive stamens, × 3; *C*, detail of calyx lobe, × 5; *D*, fecundated ovary, × 3; *E*, *F*, *G*, fruits, three forms, natural size; *H*, *I*, *J*, seed, dorsal, ventral and side views, natural size.

The flowers, diœcious by abortion of stamens or pistils, are minute, solitary or paired, sessile or very short stalked. In the staminate form the calyx tube, about 3 mm. long, is obconic campanulate, with blunt triangular teeth; glabrous or faintly

[1] From incomplete material collected by Gen. Frémont this species was made the basis of a new genus by Dr. Torrey in 1853, the Latin description of which is rendered in English as follows:

Emplectocladus n. gen.—Calyx obconical campanulate; tube not at all contracted at the naked throat; limb divided into five equal parts, persistent. Petals 5, erect-spreading. Stamens 10 to 13, biserial, pistils 1 to 2 (generally solitary), unilocular; ovules two, collateral, pendulous. Style very short, thick, slightly oblique, stigma capitate. Fruit ——.

California shrub, very much branched; branches rigid, spreading, subspinescent; leaves minute, spatulate, from subglobular buds, almost fascicular; stipules minute, deciduous; flowers subsolitary, sessile, terminal, small.

[2] Only the most careful inspection of very young leaves as they emerge from the bud will discover that they are conduplicate. The adhering margins of the linear-spatulate leaves hold them in a tubular form as they expand, giving them a rolled appearance which is accented by a slight twist.

puberulous without and minutely hairy on the inner surface. Ten or twelve stamens on short filaments are arranged in two series. The petals, 2 mm. long, are white, broadly obovate cuneate, with erose margins and without claw.

In the pistillate form the calyx tube is rather more campanulate. There are minute abortive stamens and the pubescent ovary is surmounted by a smooth style, 2 to 3 mm. long. The mature fruit, borne on a very short peduncle, is coarsely pubescent, irregularly globose, 1 to 1.3 cm. long, having a distinct ventral ridge with a shallow furrow through the center and two or three pairs of small concentric ridges arising from the base and disappearing toward the rounded apiculate apex.

The thin, dry pericarp does not split as in *Prunus andersonii* and *P. eriogyna*. The thin-walled stone is smooth surfaced excepting minute sharp ridges corresponding to those of the outer surfaces. Kernel scarcely edible because of the strong prussic-acid flavor.

Mr. F. V. Coville seems to have been the first to notice that the flowers of this species were otherwise than perfect. His description contains the following paragraph:

The flowers are polygamo-diœcious, a fact which explains Dr. Gray's difficulty [1] in identifying Torrey's plants with others subsequently collected. In the prevailingly male flowers the petals in our specimens are elliptical lanceolate, appressed strigose on the back, 3 to 3.5 mm. long; the filaments 2 mm. and the anthers 1 to 1.2 mm. in length, while the style is 1 to 2 mm. long, and the pistil sterile. In the fertile flowers the petals are ovate, glabrous on the back, 2 to 3 mm. long, the filaments 0.6 to 0.8 mm., the anthers 0.4 mm., and devoid of pollen, and the style about 2 mm. long. The sterile flower is the one figured by Torrey (loc. cit., pl. v). The form and length of the petals probably vary considerably.[2]

Schneider [3] recognizes this and the two following species as "subdiöcisch" (subdiœcious).

THE TEXAS ALMOND

The Texas almond, first collected by Lindheimer south of New Braunsfels, Comal County, Tex., "not far from Cebolo Cr.," occurs in the northwest suburbs of San Antonio and occupies an imperfectly known region southwestward to the Rio Grande and beyond [4] apparently restricted to the limestone soil of the Cretaceous formation. (Fig. 2.)

The region of the lower Pecos near the Rio Grande is one of deep deposits of soft cretaceous limestone rock, deeply eroded and very broken. The soil over the hills is often very thin or the bare rock is wholly exposed. In the broader washes some soil is beginning to collect in the form of miniature bottom lands, occasionally overflowed by the run-off from heavy rains. Along these washes there is sometimes a fringe of scrubby growth of hackberry, oak, the western black walnut (*Juglans rupestris*), the "chapote," or Mexican persimmon (*Diospyros texana*), and similar arid land forms. It is in these situations that the Texas almond is found

[1] Proc. Amer. Acad. x., p. 70 (1874).

[2] Coville, F. V. Botany of the Death Valley expedition. Contrib. Nat. Herbarium. v. 4, p. 91, 1893.

[3] Schneider, C. K. Illustriertes Handbuch der Laubholzkunde, Bd. 1, Lfg. 5, Jena, 1906, p. 598.

[4] " . . . Gravelly places and ravines between Devil's River and the Rio Grande; also in Chihuahua; Parry. Bigelow." Torrey, John. Botany of the boundary. Emory, W. H. Report of the United States and Mexican Boundary Survey . . . v. 2, Washington, 1859, p. 63.

rather than in strictly upland conditions, though in a few instances it was found on high ground, where it benefited by no addition to the rainfall by means of run-offs.

The Texas almond is a shrub scarcely 6 meters high in its northern range. Where it was studied by the writer in Valverde Co., Tex., along the limestone washes, it frequently forms thickets from 1 to 1.6 meters in height, with stems 2 to 3 cm. in diameter.

The diœcious habit of this plant is one of its most marked characteristics, when one has the opportunity of examining the plants in large numbers in its most favorable conditions.

The bushes bearing the staminate flowers are much more numerous than the fruiting ones and the flowers more numerous and crowded, so that in the field it is generally possible to distinguish the types from a distance. The examination of a large number of plants in flower in Valverde County failed to show a single case in which the flowers could be called polygamo-diœcious. In no case were hermaphrodite and unisexual flowers found on the same plant. Not a pistillate flower was found with fertile stamens nor a staminate flower that did not have the pistil abortive and much reduced in size.

During seasons of drought and scarcity of forage these bushes are browsed by stock on these ranges. In the suburbs of San Antonio, where the grazing of cows has been heavy on vacant lots, these bushes were fround cropped back to a very small size and nearly all affected with crown-gall.

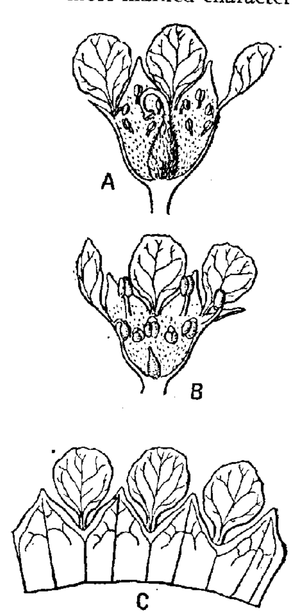

FIG. 7.—*Prunus minutiflora* Engelm.: *A*, Section of flower of pistillate form, showing well-developed pistil and abortive stamens, × 4; *B*, section of flower, staminate form, showing well-developed stamens and abortive pistil, × 4; *C*, detail of calyx lobes and petals, × 4.

Field study of two seasons of this species in flower and fruit has furnished the material for the following revised description (Pl. XV.):

Prunus minutiflora Engelm. (Fig. 7.)

Prunus minutiflora Engelm., in Gray, A., Pl. Lindheim., pt. 2, Boston Soc. Nat. Hist., v. 6, p. 185, 1850.
Cerasus minutiflora (Engelm.) Gray, in Pl. Wright, pt. 1, p. 68, 1852.
Amygdalus minutiflora (Engelm.) W. F. Wight, in Dudley Mem. Vol., p. 130, 1913.
Illus., Schneider, C. K., Laubhk., Lfg. 5, p. 598, fig. 335, m, n, o, p.

An erect but much-branched, angled and spiny shrub, from 0.5 to 1.6 meters high, stems 1 cm. to 3 cm. in diameter, forming considerable thickets along limestone slopes and washes in the cretaceous section of central and western Texas.

Twigs of young growth often puberulous, reddish brown or silvery gray; older wood with silvery gray or iron-gray bark.

The leaves, which are conduplicate in the bud, borne singly on young growth but fascicled on short spurs on older wood, are spatulate or narrowly elliptical; apex rounded, retuse or mucronate; base cuneate, entire or with one to several minute teeth on either margin, and rarely one or two near the base, glandular tipped, firm and leathery, pale bluish green, glabrous or faintly puberulous at the base, 1 to 3 cm. long, 0.5 to 1 cm. wide; petiole short, slender; stipules 2 mm. long, acuminate, ciliate margined.

The minute flowers, borne singly or paired, on short peduncles, are usually crowded on short, budlike fruiting spurs. They appear with the leaves in February or March and are minute and diœcious by the abortion of the stamens in the fruiting form and of the pistils in the opposite form. In both types the inner surface of the calyx is finely hairy. In the pistillate type the calyx tube is obconic, glabrous; lobes triangular, acute; peduncle 3 mm. long, puberulous; ovary and lower portion of the style finely pubescent. There are usually 15 or more abortive stamens. Petals white, about 2 mm. long, obovate cuneate, with sinuous or erose margins and short, stout claws.

In the staminate flowers the tube is slightly broader, the stamens 10 to 15 or rarely 16 to 20 on short filaments, usually with a stamen opposite each petal, one or two against each calyx tooth, and an irregular number disposed on the upper surface of the tube. The pistil is abortive and much reduced.

Fruit globose, apiculate and with shallow ventral furrow, pubescent, 1 to 1.5 cm. long, the thin, dry sarcocarp scarcely dehiscent; the stone smooth with but a slight furrow on ventral surface.

THE MEXICAN ALMOND

The Mexican almond was the first of this group to be described, but to-day is the least known of all of them. Found in the high mountain regions of Mexico, it has been little collected and it is not known that it has as yet been brought into cultivation.

Judged by the pubescent thin-fleshed fruit with its smooth, oval stone its relationship would be considered near to the Texas almond (*Prunus minutiflora*) which crosses the border into Chihuahua, but its more slender and less spinose twigs and especially the serrate, finely pubescent leaves indicate that it is a quite distinct species. In 1823 Humboldt and Bonpland found it growing in arid hills between Pachuca and Moran (Estado de Hidalgo) at an altitude of 7,800 feet and describe it as a shrub 3 feet high with sparse, reflexed, divergent, glabrous branches and subangular pubescent twigs.

Parry and Palmer collected this shrub in the region of San Luis Potosi at an altitude of 6,000 to 8,000 feet, which would agree well with the altitude at which the original specimens were collected by Humboldt and Bonpland.

The majority of specimens in American herbariums have been collected by Mr. C. A. Purpus, of the University of California, to whom the writer is indebted for the most recent information on the occurrence and habits of this species.

The following description of this species is made from material in the United States National Herbarium, specimens contained in the herbarium

of the University of California, and material collected by Mr. Purpus for the writer:

Prunus microphylla Hemsley.* (Fig. 8.)

Amygdalus microphylla, H., B., and K., Nov. Gen. et Sp. Pl., v. 6, p. 243, pl. 564, 1823.[1]
Prunus microphylla (H., B., and K.) Hemsley, Biol. Centr. Amer. Bot. v. 1, p. 118, 1879.
Illus., Schneider, C. K., Laubhk., Lfg. 5, p. 598, fig. 335, q, r, s, t; H., B., and K., loc. cit.

A low branching shrub with slender twigs destitute of thorns; puberulous on new growth, sometimes also on wood of second year, bark greenish or reddish brown, turning to silvery or dark gray on older wood. Leaves narrowly elliptical or on fresh shoots broadly lanceolate; base slightly produced or cuneate; margin crenately serrate with blunt glandular or callus tipped teeth; dull green, faintly puberulous above; grayish green with scattered short hairs on the lower surface; nearly glabrous on old growth; 1.5 to 2 or 3 cm. long; petiole short, puberulous; stipules 2 to 3 mm. long; slender attenuate, russety, hairy with glandular teeth; stomates not present in upper surface of the blade.

The flowers, appearing in April or May before or with the leaves, are solitary, minute, and diœcious by the abortion of the stamens or pistils.

Staminate flowers sessile, with glabrous campanulate calyx tube 2 to 3 mm. long; lobes short, triangular, with expanded base and glandular ciliate margins; tube minutely hairy within; petals white, broadly obovate, entire or with notched or erose margins. Claw short or wanting. Stamens on filaments 1 to 2 mm. long are 10 to 15 or 18 in two or three circles, one circle opposite the petals, one opposite the calyx lobes near the throat, and a more or less complete circle below these. (One flower had 15 stamens and the three circles complete.) The pistil is minute, glabrous, and abortive.

In the pistillate form the stamens, with very short filaments, are abortive; the pistil, 4 to 5 mm. long, has the ovary and lower portion of the style pubescent; stigma expanded.

The mature fruit is 1 to 1.5 cm. long, oval with about equally rounded ends, apiculate by persistence of the style, but little compressed, densely rusty pubescent; sarcocarp

[1] Their description is translated as follows:

Amygdalus microphylla. Tab. DLXIV.

Amygdalus oblong, acute, mucronate, crenate-serrulate with glabrous leaves.

Grows on arid hills, between Pachuca and Moran, alt. 1,300 hex. (7,800 ft.). (Mexico) *Shrub. Flowers in May.*

Shrub 3 feet high, very much branched; branches spreading divergent, reflexed, rounded, smooth, glabrous, blackish; twigs subangular, pubescent. Leaves sparse, petiolate, densely fasciculate on shortened branches, oblong, acute and mucronate, somewhat acute at the base, crenate-serrulate, the teeth with glandular midrib, reticulate-veined, prominent below, membranaceous, glabrous, with scattered, very minute scurfy dots above, 5 to 6 lines long, 2 to 2½ lines wide. Petioles 1 line long, canaliculate, puberulous. Stipules linear-subulate, serrulate-glandular below, pubescent, twice as long as the petiole. Flowers axillary, solitary, with very short peduncles, scarcely as large as the flower of *Amygdalus incana;* peduncle scarcely half a line long, thick, glabrous, subtended by several imbricate, ovate, purplish, glabrous bracts. Calyx (figs. 1 to 3) subturbinate-campanulate, limb 5-parted, reddish, glabrous, later split around above the base and deciduous, with ovate laciniæ, denticulate-glandular at the margin, 3-veined, equal, reflexed. Petals (fig. 5) five, inserted in the throat of the calyx, alternating with the laciniæ of the latter and twice as long, unguiculate, obovate, entire (2-parted fide Bonpl.), white, glabrous (this I saw formerly in specimens no longer at hand), fallen from the specimens at hand. Stamens (fig. 4) about 14, slightly shorter than the laciniæ of the calyx; of these 4 inserted in a tube towards the middle; 10 around in a border (five opposite the laciniæ of the calyx, five opposite the petals). Filaments subulate, glabrous. Anthers subrotund, affixed dorsally, exposed (figs. 6 to 7), deeply trisulcate in front, bilocular, longitudinally dehiscent on the inside. Ovary (figs. 8 and 9) free, sessile, oblique ovate, somewhat compressed, shorter than the calyx tube, sericeous, unilocular (fig. 10); ovules (fig. 11) two, ovate, side by side, suspended below the apex, pendulous. Style terminal, filiform, exserted, glabrous. Stigma (fig. 12) dilated, peltate. Fruit (not seen) globular, monospermous (fide Bonpl.).

Varies in a 6-parted calyx.

thin and dry, probably slightly fleshy when nearly ripe, splitting tardily along the ventral suture. Three or four pairs of shallow concentric furrows sometimes radiate from the base. Stone rounded oval with apiculate apex, smooth, with a slight ventral ridge and a faint dorsal furrow.

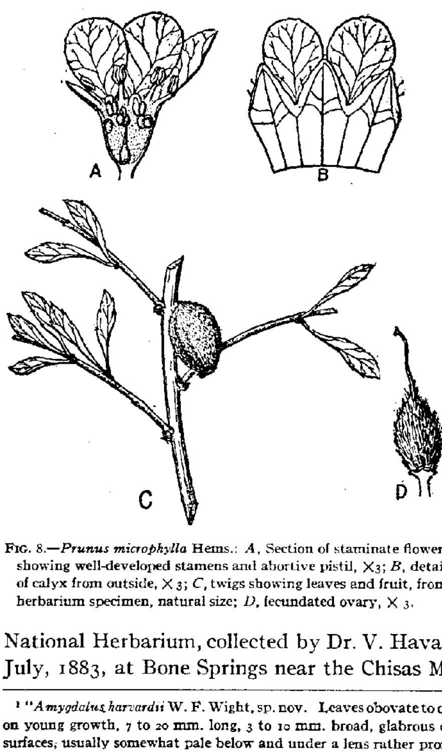

FIG. 8.—*Prunus microphylla* Hems.: *A*, Section of staminate flower, showing well-developed stamens and abortive pistil, ×3; *B*, detail of calyx from outside, ×3; *C*, twigs showing leaves and fruit, from herbarium specimen, natural size; *D*, fecundated ovary, ×3.

Prunus microphylla is intermediate between *P. fasciculata* and *P. minutiflora*, but differs from both in the glandular leaf serrations. The absence of stomates in the upper surface is a noticeable difference from *P. fasciculata* and would ally this species most closely with *P. minutiflora*.

HAVARD'S ALMOND

Prunus havardii W. F. Wight, n. comb.[1] (Pl. XVI.)

This species, the least known of the group, was recently described by Mr. William Franklin Wight, Bureau of Plant Industry, as from specimen No. 138851, United States National Herbarium, collected by Dr. V. Havard, United States Army, in July, 1883, at Bone Springs near the Chisas Mountains. This locality is

[1] "*Amygdalus harvardii* W. F. Wight, sp. nov. Leaves obovate to oblong-obovate or sometimes fan-shaped on young growth, 7 to 20 mm. long, 3 to 10 mm. broad, glabrous or sometimes finely pubescent on both surfaces; usually somewhat pale below and under a lens rather prominently reticulate veined, the margin conspicuously dentate toward the apex, very rarely toothed below the middle, the teeth usually acute and apparently glandless. Flowers appearing with the leaves and sessile; calyx slightly pubescent, the tube about 2.5 mm. long, the lobes scarcely more than 1 mm. long, entire and obtuse; petals not seen. Fruit sessile, nearly globular, the pubescent exocarp dehiscent along one edge, when dry about 9 mm. long, 7 mm. broad, and 7.5 mm. thick; stone about 8 mm. long, 6.5 mm. broad, and 7 mm. thick, rounded at the base and slightly pointed toward the apex, the surface smooth except for indistinct grooves near the ventral edge.

A shrub with rather rigid branches, stout spinescent branchlets, and light gray bark. The type specimen in the United States National Herbarium was collected in fruit by V. Havard in July, 1883, in western Texas, east of the Chisas Mountains, near Bone Springs. It was also collected by C. C. Parry, J. M. Bigelow, Charles Wright, and A. Schott on the Mexican Boundary Survey under the direction of Major W. H. Emery, this specimen being labeled 'chiefly in the valley of the Rio Grande, below Doñana.' The species is most closely related to *Amygdalus microphylla* H. B. & K. of Mexico, but is easily distinguished by its broader, more obovate leaves as well as by their reticulate venation and eglandular margins." Wight, W. F. North American species of the genus Amygdalus. Leland Stanford Jr. Univ., Dudley Memorial Volume, p. 133, 1913.

The spelling of the specific name *harvardii* is a typographical error, as the type specimen was collected by Dr. V. Havard.

in the southern part of Brewster County, Tex., at about the southern extremity of the bow of the Big Bend of the Rio Grande.

The description cites also one specimen from the Mexican Boundary Survey Collections, No. 338. As both specimens show only matured fruit, it is difficult to place this species with reference to *Prunus minutiflora* and *P. microphylla*, to which it appears to be nearly related, both in the character of the fruit and in the absence of stomates in the upper epidermis of the leaves. In its abruptly angled and thorny branchlets and nearly eglandular leaves (Pl. XVI) it would seem to be most nearly related to *P. minutiflora*. Whether it will agree with the above species in the diœcious character of the flowers, small number of stamens partly placed on the face of the calyx cup and in the finely hairy inner surface of the cup can only be determined from complete material. It is provisionally placed in the subgenus Emplectocladus of Prunus.

DESCRIPTION OF PLATES

PLATE IX. Fig. 1.—*Prunus texana:* Better quality of fruit. Natural size.
Fig. 2.—*Prunus texana:* Fruiting bush, 2 meters in diameter.
Fig. 3.—*Prunus texana:* Seeds; three scraped clean of pile. Natural size.

X. Fig. 1.—*Prunus texana* hybrid, hort. var. *Stuart:* Fruit and leaves. Natural size.
Fig. 2.—*Prunus texana* hybrid, hort. var. *Stuart:* Tree in first leaf.
Fig. 3.—*Prunus texana* hybrid, hort. var. *Johnson:* Fruiting branch. Natural size.

XI. Fig. 1.—*Prunus andersonii:* Plant, showing taproot.
Fig. 2.—*Prunus andersonii:* Flowering branch. Photographed by Vincent Fulkerson.
Fig. 3.—*Prunus andersonii:* Types of seeds. Natural size.

XII. Fig. 1.—*Prunus andersonii:* Tangled thickets, the more common form.
Fig. 2.—*Prunus andersonii:* Treelike specimen, 3 meters high.
Fig. 3.—*Prunus eriogyna,* n. sp.: Erect, large-leaved form of plant.

XIII. Fig. 1.—*Prunus eriogyna,* n. sp.: Common form of plant.
Fig. 2.—*Prunus eriogyna,* n. sp.: Variable fruits and seeds.
Fig. 3.—*Prunus eriogyna,* n. sp.: Fruiting branch. Natural size.

XIV. Fig. 1.—*Prunus eriogyna,* n. sp.: Seedlings.
Fig. 2.—*Prunus fasciculata:* Growth in flood-swept wash.

XV. *Prunus minutiflora:* Fruiting branch. Natural size. Photographed by S. H. Hastings.

XVI. *Prunus havardii:* Fruiting branch of the type specimen.


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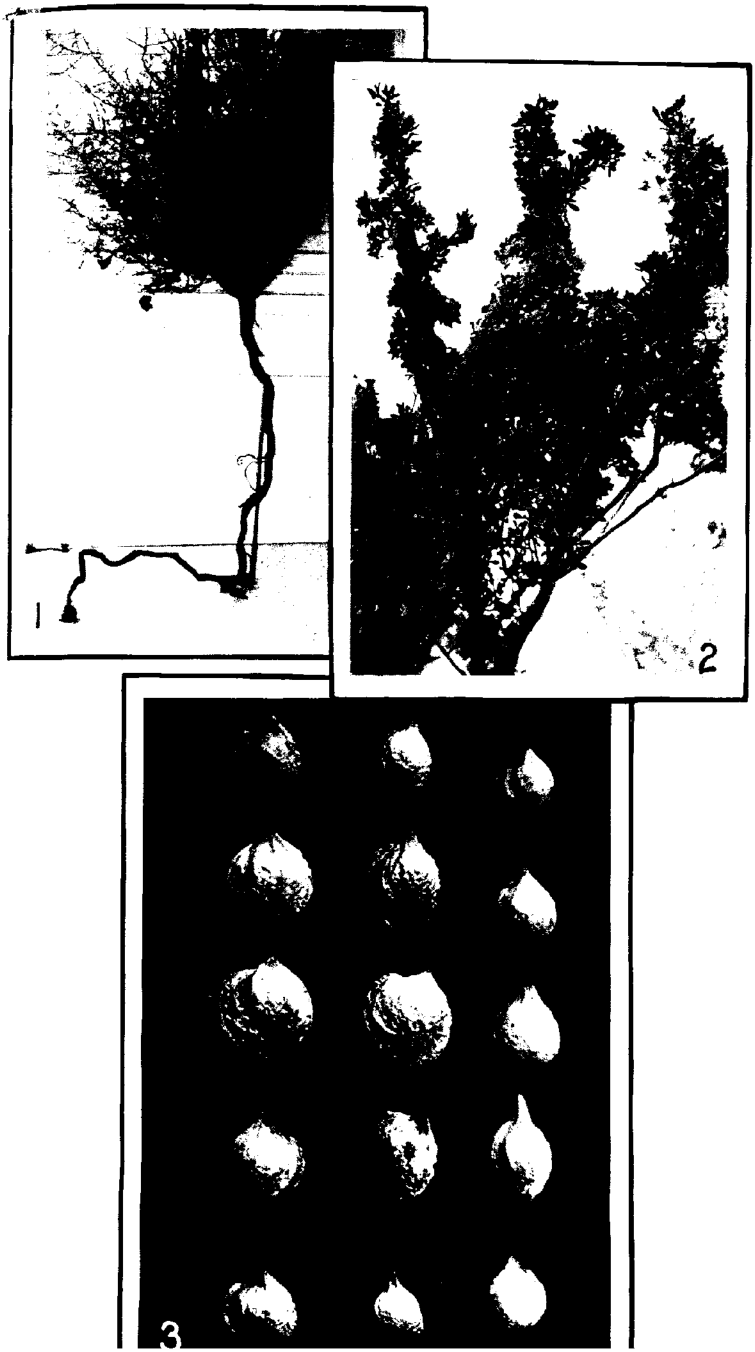
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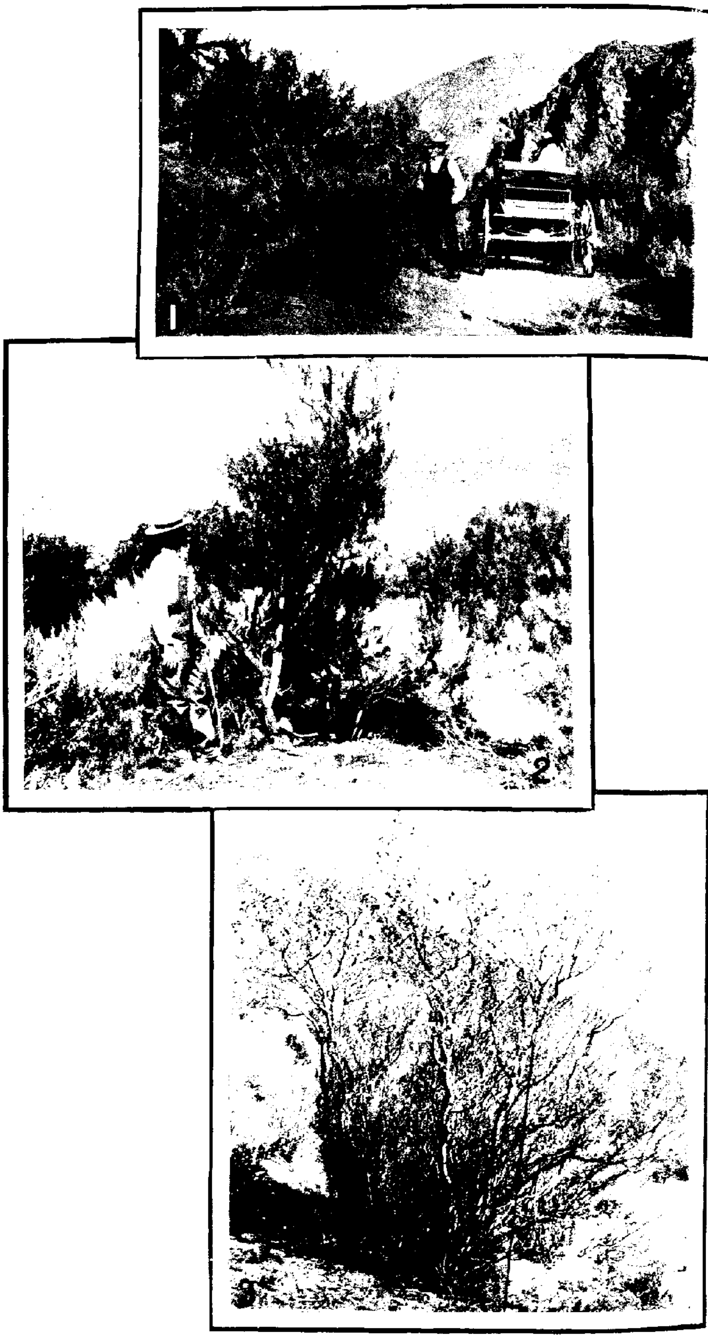

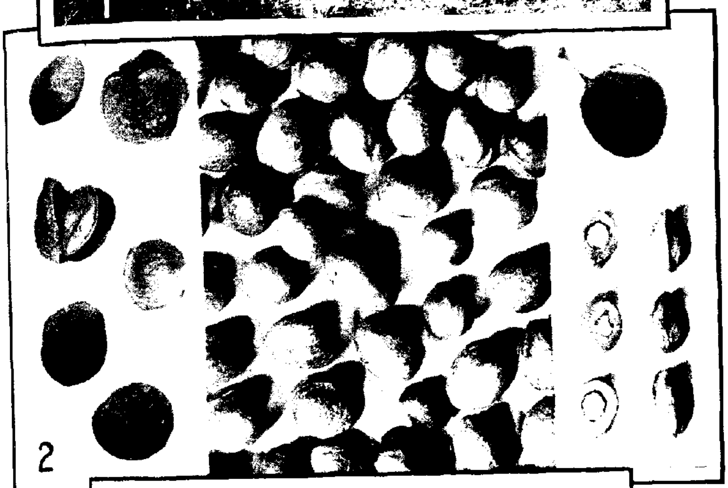

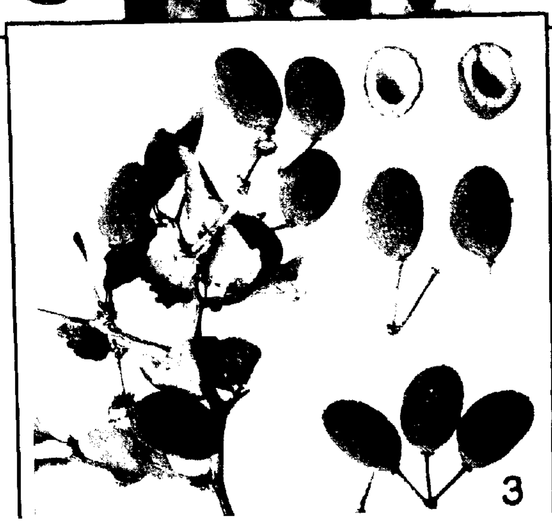

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